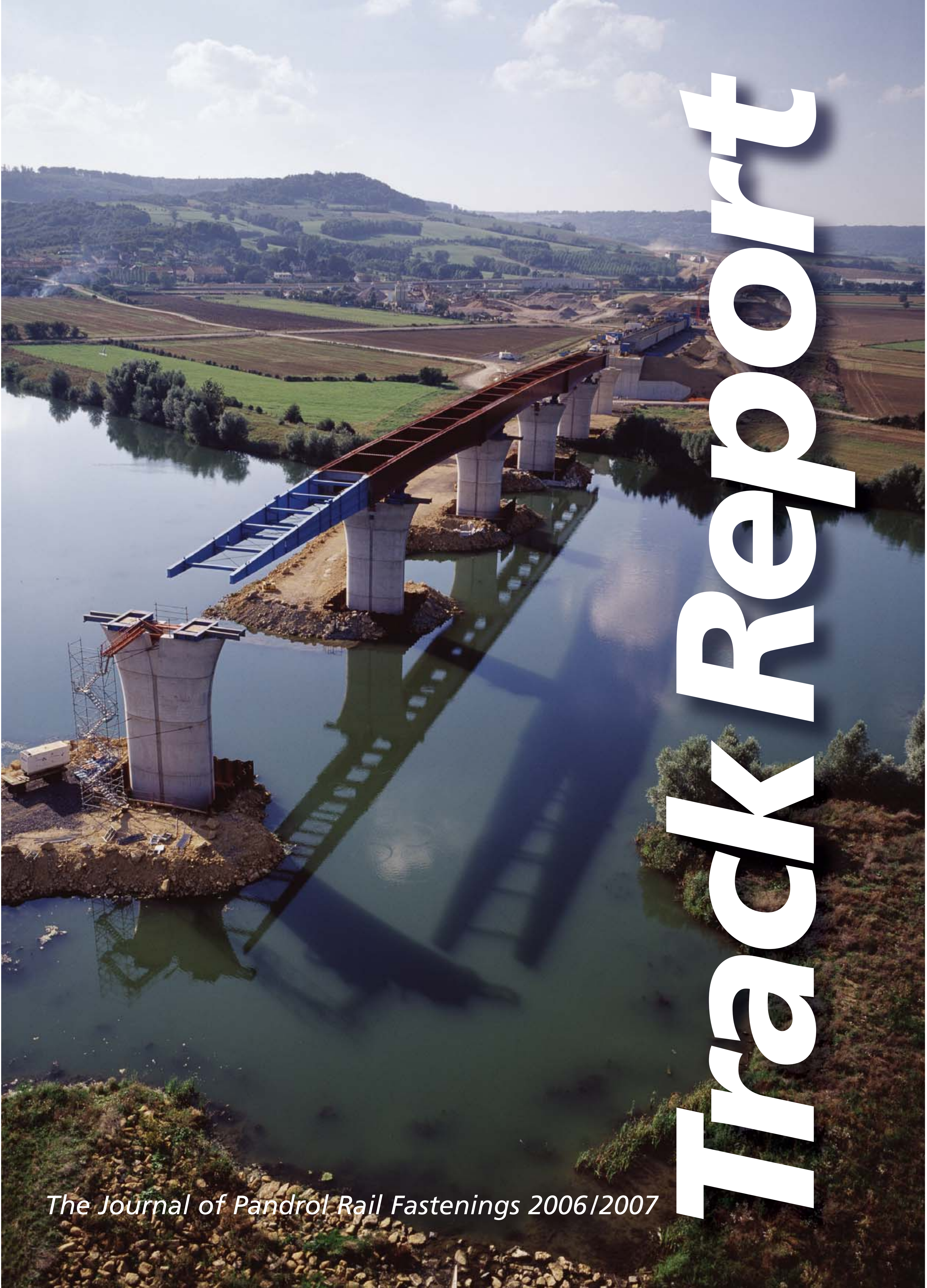
Track Report



The Journal of Pandrol Rail Fastenings 2006/2007

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Front Cover: 'Track Construction on the new LGV Est.'
The Moselle Viaduct is the longest bridge in Phase 1 of the LGV Est, with a length of 1510 metres and height of 20 metres.

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PANDROL
DELACHAUX GROUP

PANDROL VANGUARD Baseplate Installed on Guangzhou Metro

By L. Liu, Director, Track Construction, Guangzhou Metro, Guangzhou, P.R. of China

The city of Guangzhou is the third largest in China, has more than 10 million inhabitants and is situated in the south of the country near Hong Kong. Construction of a subway network was approved in 1989 and construction started in 1993. Five years later, the city, in the south of one of the world's most populous countries, could boast a two-line metro system, which uses some of the latest light-rail technology, and was a model for a completely integrated project. Line 1 opened in 1999 has a total length of 18.5 km with 16 stations, of which 16km are underground with 14 stations below ground, and runs from the Guanghzou Iron and Steel Works in the south-western suburb of Fangcun, crosses the Pearl River, and traverses the busy commercial district along Zhongshan Road to the East Railway Station, which is the terminus for the main line to Hong Kong. Line 2 is 23.3km long with 20 stations, 17 of which are underground. Construction started in 1999 and opened in April 2003. A third 36 km Line 3, consisting of 23 stations, will run from the city's Tianhe Railway Station and cross the Pearl River to the city's Panyu District, located at the mouth of the Pearl River. Line 3, described as a high speed light rail line, began construction in 2002. Opening date is scheduled for 2006. Further expansion is proposed with the 18km Line 4 from Science Town to Pazhou and Line 5, running for 35km from the new Guangzhou Baiyun Airport to East Railway Station in Guangzhou. A total of 7 lines and 206 km are planned for the final build-out. Contrary information cites a 5 line system with 129 km to be completed by 2010.

Owing to the proximity of the railway to residential, commercial, educational and hospital developments it is often necessary to attenuate noise and vibration levels to a minimum in order to satisfy environmental requirements. A high level of vibration isolation track form has to be used to control railway vibration transmission in environmentally sensitive areas. Pandrol VANGUARD system has been selected for these requirements on Line 3 and Line 4 which are under construction.

PANDROL VANGUARD TRIAL ON GUANGZHOU METRO LINE 1

A track trial of 192 m length of Pandrol VANGUARD vibration control rail fastening baseplates on Line 1 of the Guangzhou Metro system (Figure 1) in China was carried out in January 2005. The baseplates were installed in place of the existing fastenings in a tunnel on the southbound track between Changshoulu and Huangsha stations.

Measurements of track deflection and vibration in the tunnel and surface vibration

Figure 1 Guangzhou Metro Route Map

DIRECT FIXATION ASSEMBLIES

Figure 2 Pandrol VANGUARD installed in a tunnel on Guangzhou Metro Line 1
(Note that conventional fasteners were removed from intermediate positions before measurements were made)

Figure 3 VANGUARD clamping tool

above the tunnel under traffic were made before and after the installation. The measurements show that significant reductions in the vibration level on the track slab and at the surface immediately above the tunnel were achieved when the Pandrol VANGUARD fastenings were installed.

The motivation for the trials was that the Pandrol VANGUARD system was being considered as an alterative to floating slab track. As well as ground borne vibration, airborne noise in trains running in the tunnel needs to be considered.

PANDROL VANGUARD RAIL FASTENING SYSTEM

Pandrol VANGUARD is a rail fastening system in which the rail is supported by elastic wedges under its head. The wedges are in turn held in place by cast iron brackets, which are fastened to a baseplate. The baseplate is rigidly fixed down to the track foundation as shown in Figure 2. The principal advantage of the system over more conventional rail fastenings is that is allows significantly greater vertical deflections under traffic without an unacceptable accompanying degree of rail roll and without increasing the overall rail height. A special clamping tool is used to assemble/ disassemble the system as shown in Figure 3.

The dynamic stiffness between 5kN and 35kN of the Pandrol VANGUARD baseplate designed for Guangzhou Metro is 6.0 MN/m. This very low stiffness system reduces vibration transmission to the supporting structure and hence into the ground.

TRACK DEFLECTION AND VIBRATION

The deflections and accelerations of both rails were measured. The vibration level was also measured on the slab, the wall in the tunnel and at the surface of Dadi Old Street, a pedestrian street, above the tunnel in which the Pandrol VANGUARD installation was made. Figure 4 shows the position of the surface measurements.

The traffic was 6 car EMUs with an axle load of approximately 16 tonnes and the maximum traffic frequency was 15 trains per hour during peak period operation. The track speed is about 70 km/h. All measurements were made under normal service passenger traffic at peak operating hours.

Measurements of track vibration were also made on the northbound track between Jiniantang and Yuexiugongyuan stations on the Guangzhou Metro Line 2. The test site has about 198m of floating slab. These measurements were made in the same way, and using the same equipment so that the vibration levels of the track with Pandrol VANGUARD system can be compared with a floating slab track.

The vertical deflections of the rail foot on the field side and the gauge side were first averaged to estimate the vertical deflections of the rail centre. Rail roll has been calculated by subtracting the gauge side deflections at the rail foot edge from field side deflections, dividing by two and multiplying by a geometry factor (rail foot divided by distance between field-side and gauge side vertical transducers). The lateral deflection of the rail head was estimated by multiplying the rail roll by an appropriate factor derived from the geometry of the rail section and adding the corresponding average lateral deflection of the rail foot. The geometry factor used in the calculation was the ratio between the height of the gauge corner of the rail and half the width of the base.

With the existing fastening system, the net average rail vertical and maximum rail head lateral deflections are 0.131mm and 0.146mm respectively. With Pandrol VANGUARD baseplates, the net average rail vertical and maximum rail head lateral deflections are 3.91mm and 0.220mm respectively.

The data shows that the Pandrol VANGUARD fastening system is a lot more compliant in the vertical direction than the system it replaces, while rail roll and lateral deflection are only slightly increased and remain at quite acceptable levels.

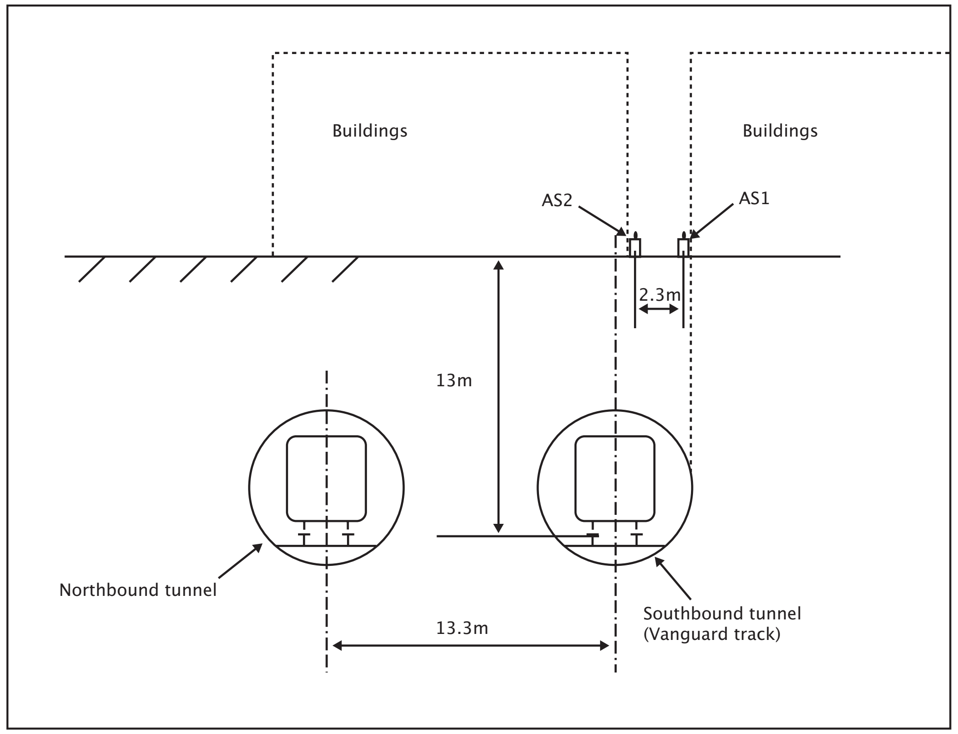


Figure 4 Approximately position of two tunnels

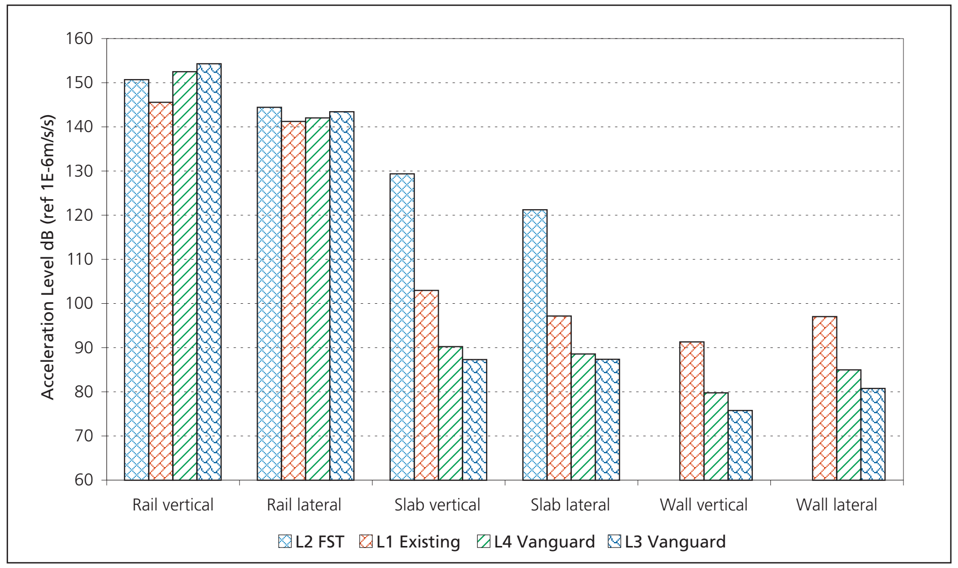


Figure 5 Total acceleration levels

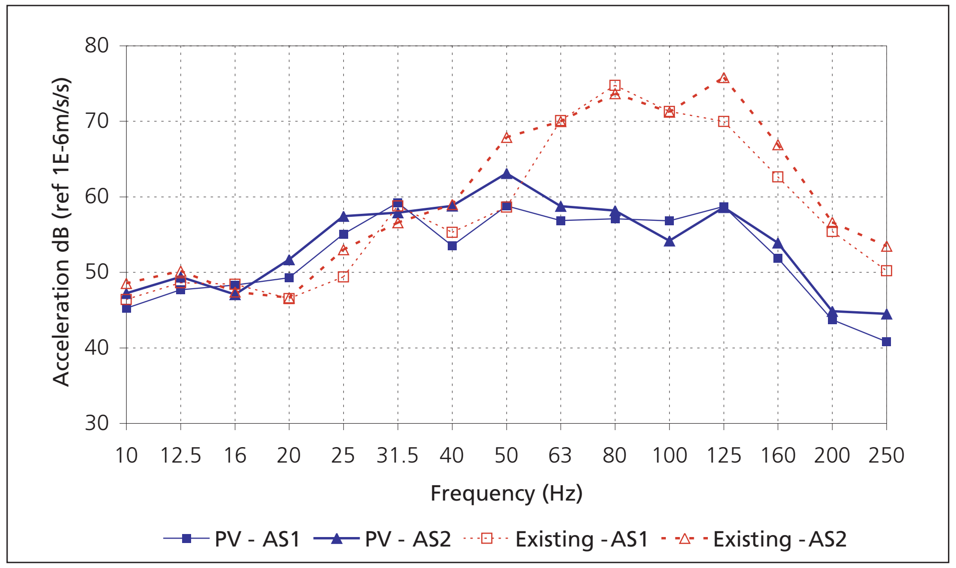


Figure 6 Surface acceleration spectra under Line 1 traffics

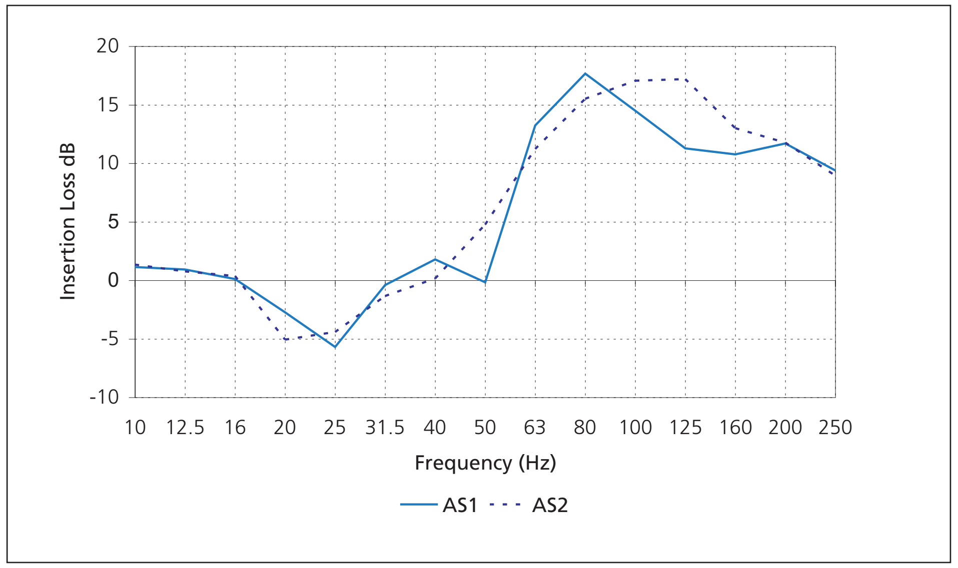


Figure 7 Surface insertion loss

This combination of low vertical stiffness and rail roll restraint with the Pandrol VANGUARD fastening system offers the potential for significant reductions in vibration transmission with a mechanically acceptable system.

Total vibration levels for different measurement positions are shown in Figure 5.

The rail vertical acceleration increased after the installation of the standard Pandrol VANGUARD fastenings. The increase in vertical rail vibration is because of the lower stiffness of the track, and the lower wave decay rate along the rail that results.

To put these changes in rail vibration into perspective, they can be compared with the results of track vibration measurements made on the floating slab track on the Guangzhou Metro Line 2. These indicate that the rail vibration levels on both the floating slab track and Pandrol VANGUARD tracks are very similar. Noise levels on track fitted with Pandrol VANGUARD are likely to be no higher than for track with floating slab track.

The total vibration acceleration level on the slab decreased by 15.6 dB as a result of the installation of the Pandrol VANGUARD baseplates. The tunnel wall acceleration decreased by 15.5 dB in the vertical direction and 16.3 dB in the lateral direction.

It should be noted that the slab vibration on the Line 2 floating slab track was quite high, more than 26 dB higher than that on the slab with the existing Guangzhou Metro rail fastening system on Line 1, and 42 dB higher than that on the slab with the standard Pandrol VANGUARD system. This high level of slab vibration will create a rumbling noise in the tunnel that is likely to be heard inside the vehicles.

The frequency range of greatest interest for the surface vibration is from 20 Hz to 250 Hz. Vertical acceleration spectra at the surface at the two locations with the existing fastening and the Pandrol VANGUARD system installed are shown in Figure 6.

Vibration acceleration levels on the surface decreased by about 11.0 dB to 68.2 dB as the result of the installation of the standard Pandrol VANGUARD system. The reduced acceleration level is under the GZM environmental limit of 70 dB in the residential area. The original level exceeds the limit by a significant margin. Figure 7 shows the insertion loss between the Pandrol VANGUARD and the existing systems. The tests have demonstrated the level of vibration reduction that can be achieved in practice under operating conditions.

The Pandrol VANGUARD baseplates remain in track on Line 1 and no adverse reports on their performance from Operating Departments of Guangzhou Metro have been received since the installation in January 2005. The decisions have been made for Line 3 and Line 4 application. However, Pandrol VANGUARD performance on track will be continuously monitored at regular intervals for the foreseeable future.

PANDROL VANGUARD INSTALLATION ON GUANGZHOU METRO LINE 3

The first installation of 700m VANGUARD track on the new Line 3 was made in February 2005, and further 880m installed in July 2005. Figures 8 and 9 show the Pandrol VANGUARD baseplate installed on track. Further planned installations including in a few tunnels on Line 3 and the airport extension will be carried out in 2006/2007.

PANDROL VANGUARD APPLICATION ON GUANGZHOU METRO LINE 4

The modified Pandrol VANGUARD configuration designed for Guangzhou Metro Line 4 with a linear induction motor (LIM) rolling stock system, was to assess the effectiveness of the system in controlling ground vibration and also to evaluate the dynamic deflection for the design on Line 4. Track test was also made on the same trial section on Line 1 for the modified VANGUARD, where the special rail pad was inserted into the standard VANGUARD assembly.

The deflections averaged across both rails between leading and trailing axles are those that are relevant to Line 4 traffic, because the pick-ups for the LIM systems are mounted on the vehicle bogies. The net average rail vertical and maximum rail head lateral deflections are 1.336 mm and 0.273 mm respectively. This process gives a dynamic stiffness of 14.3 MN/m for the modified Line 4 Pandrol VANGUARD baseplate which has met the design specification.

Vibration acceleration levels on the slab decreased by about 12.7 dB as the result of the installation of the modified Line 4 Pandrol VANGUARD assembly. The tunnel wall acceleration decreased by 11.5 dB in the vertical direction and 12.1 dB in the lateral direction.

A 300m of VANGUARD baseplates on Line 4 phase 1 was installed in July 2005. ■

Figure 8 Pandrol VANGUARD installed on Guangzhou Metro Line 3

Figure 9 VANGUARD Site inspection by GZM Managing Director and his Engineers on Line 3

Extension of the Docklands Light Railway to London City Airport (CARE project)

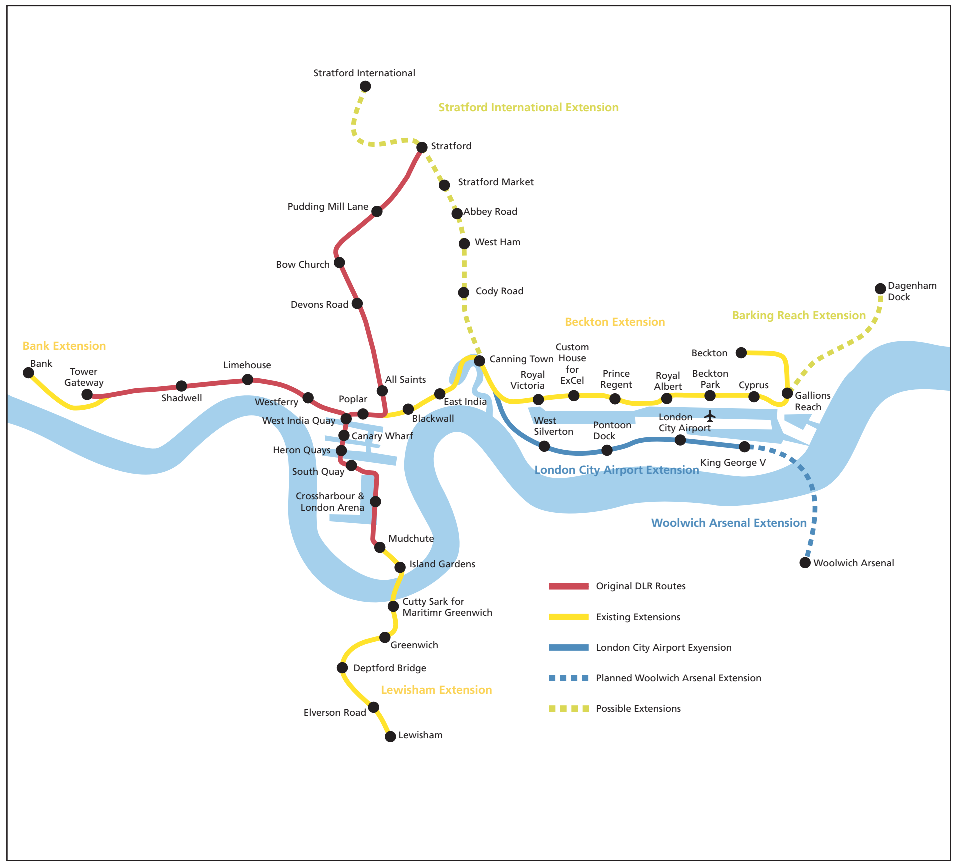
The Docklands Light Railway (DLR) is a major success story for the light rail industry in the UK and has embarked on a series of major expansions to its network. The extension of the Docklands Light Railway to London City Airport was awarded to City Airport Rail Enterprises PLC, "CARE" an AMEC / Royal Bank of Scotland company which is responsible for design, build, finance and maintenance of the extension for a period of 30 years. The extension creates a new spur of track from the existing line to Beckton, tying into the existing line at a new junction east of Canning Town station. The new line sweeps south-east to King George V dock, for 4.5km of twin track, creating four new stations and an important alternative route to the London City Airport.

The design challenge presented by the new route was to thread a railway along an existing transport corridor, with both commercial and residential buildings in close proximity to the new railway. The railway is largely elevated on viaducts, which amount to 3.7km of the total length, representing over 80% of the track. The proximity of these concrete box structures to neighbouring premises creates a requirement to eliminate secondary re-radiated noise from the structures. It was established early in the design process that a resilient trackform is necessary to reduce the transmissions of vibration into the structures. AMEC, using the consultants Halcrow, calculated that a target resilience of 29 kN/mm was necessary to mitigate the vibrations sufficiently to protect the neighbours of the railway from unacceptable levels of railway noise. Where the railway passes extremely close to existing buildings, additional airborne noise barriers are being installed.

The rail size chosen for the CARE project is BS80A, which matches the rest of the DLR network. The PANDROL VIPA-SP system was selected because the baseplate meets the low target stiffness and because it is delivered to site preassembled and is ready to install. The very slim viaduct sections dictated that the installed track design achieved a low dead weight. It was decided to use a top-down construction with grout pads, by hanging the VIPA-SP assemblies from rail, and holding the entire track with jigs. The design of the jig was crucial to the efficiency of the installation method. The jig held the rail by the foot, and at the correct inclination, in order that the head of the rail was unrestricted and a path was continually available for material trolleys, drilling equipment, and road / rail excavators.

Proximity of residential buildings demanded 'soft' track

Gantry crane installing prefabricated viaduct segments

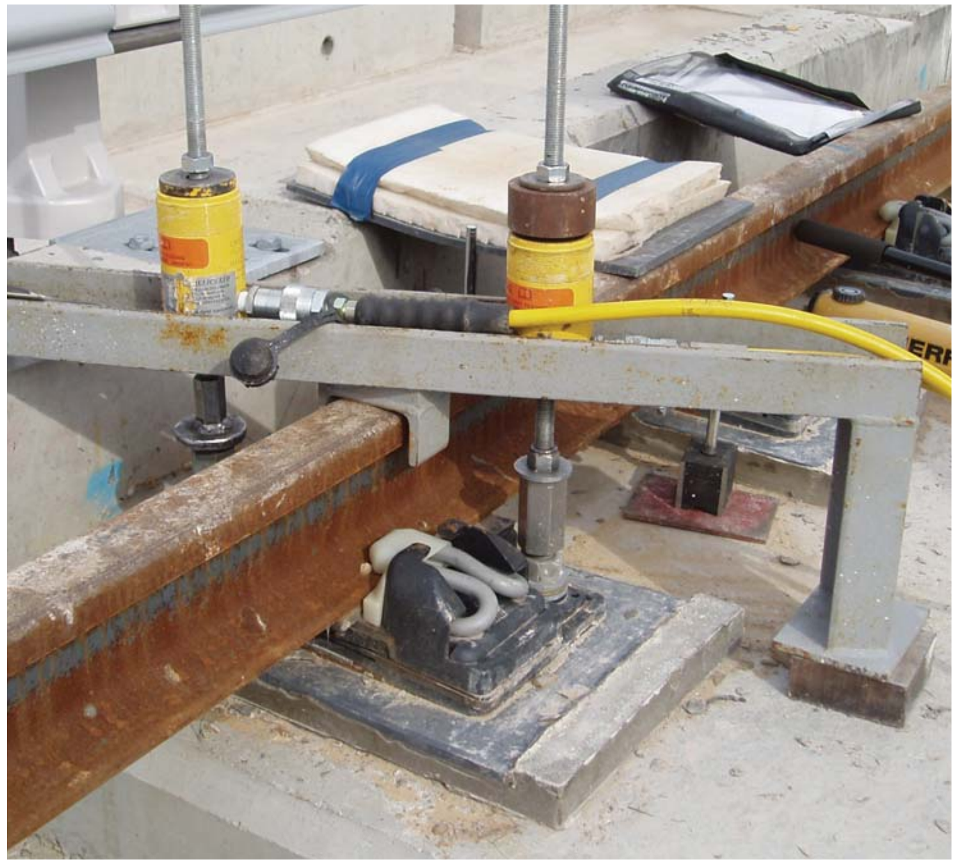


Track alignment checked prior to drilling for bolts.

Repeated load test in the laboratory

Formwork placed ready for pouring grout.

Drilling through to fix bolts

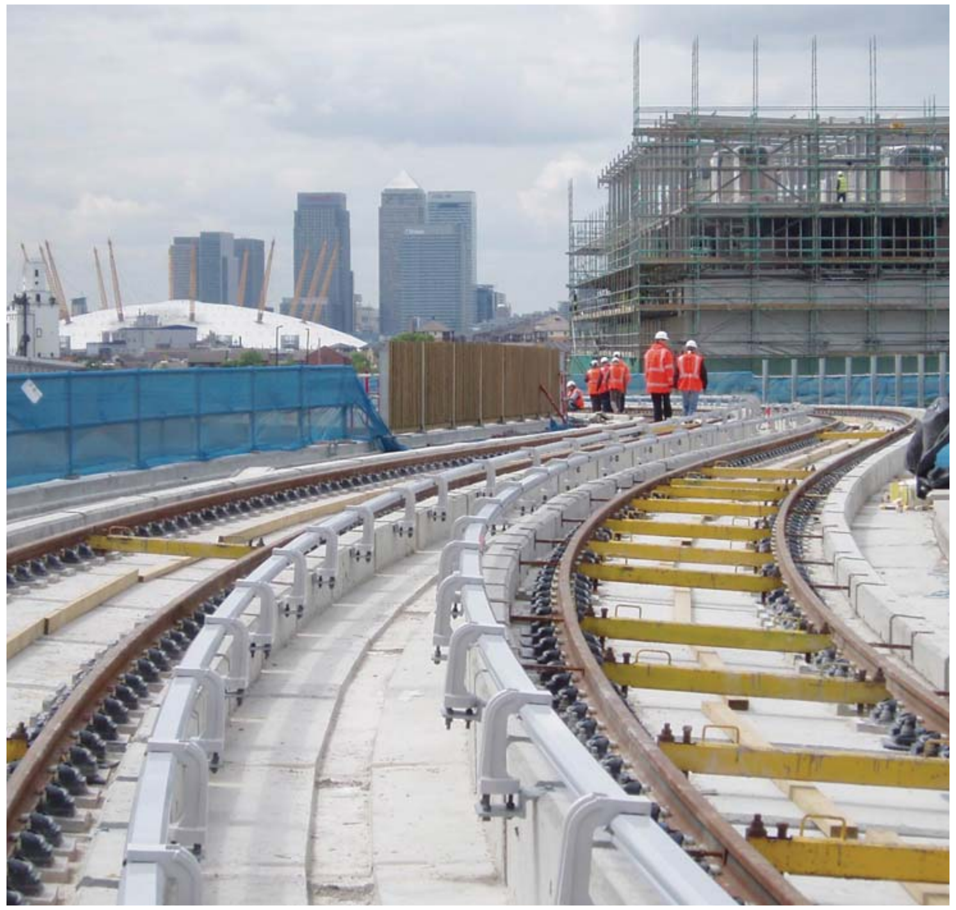


Proof load test on the anchor bolts on site

The method was to mark the position of the baseplates, and scabble the concrete to provide a good key for the grout. Once the baseplates were laid out, the fastenings were applied to the rail, jigs positioned and the track jacked into vertical and horizontal alignment. A rail mounted drilling trolley with Hilti twist drill was used to drill through the drilling collars provided with the VIPA-SP baseplates. Epoxy glue was injected into the holes and the hold-down assemblies inserted from the top of the plates. Once the epoxy was cured and set, the formwork for the grout pad could be positioned around the construction shim, any gaps sealed with clay. The temperature and humidity had to be carefully controlled during the pouring of the grout, to ensure good contact with the construction shim and the concrete. In the worst of winter conditions, tents and heaters were used to maintain a minimum temperature of 4 degrees. Once the grout pad was cured the bolts could be 'torqued' to the specified level, and each rail seat cleaned to high standard.

The performance and dimensional requirements were incorporated into the tailored design of the Pandrol VIPA-SP baseplate produced for the DLR and data was provided to allow the system to be formally accepted by the client organisations. The route has many curves of less than 250m radius, and the minimum radius is 65m. For curves below 250m radius the stiffness of the baseplate assemblies has to be 'tuned' in order to limit rail-roll. The stiffness is tuned by changing the rail pads, which stiffens the assembly on the tightest curves. In some areas beside expansion joints it was necessary to allow the rail to expand at different rates to the bridge deck, so the VIPA-SP assemblies were fitted with a different toe-insulator on the FASTCLIP. This toe-insulator applies the toe-load on the side insulator whilst maintaining full pressure. If the rail rolls, this is immediately held

Rail free assemblies



Track jigs hold the rails especially on tight curves

by the toe-load as the rail rotates. However, the rail can expand beneath the clip due to thermal expansion.

Laboratory testing was undertaken on rail fastening assemblies to measure the main performance characteristics, including durability, static and dynamic stiffness, toe-load, and pull-out strength. Pandrol worked closely with AMEC SPIE Rail to develop a suitable method for installation using an adapted form of 'top-down' construction to close the gap between the top of the concrete slab track on the viaducts and the much tighter tolerance required on the position of the track.

The project was completed during the summer of 2005, with commissioning during the autumn and the route opened to traffic as planned during December 2005.

The next phase of the DLR extension will be a tunnel under the Thames extending the line beyond the current terminus at King George V station to link Woolwich Arsenal to the DLR network. AMEC in partnership with the Royal Bank of Scotland has been awarded the contract for the further phase to Woolwich Arsenal. The current design phase is again considering the Pandrol VIPA-SP system for most of the slab-track sections in the tunnel, with Pandrol VANGUARD for the most sensitive areas. ■

Completed track

PANDROL DOUBLE FASTCLIP installation on the Arad Bridge

The town of Arad is situated in the Transylvania Region of Northwest Romania, near the banks of the river Mures, and about 100km east of the River Tisa.

Accelerated development of industry in and around Arad was followed by a significant growth in population and in the 1980's Arad had over 150,000 inhabitants.

In order to deal with the growing need for housing, new districts consisting of blocks of apartments were built. The commercial and services network was expanded, and the railway network developed and extended.

Today, an important international freight and passenger rail route links Romania and Hungary via the city of Arad. The railway passes close to the residential flats in Arad before crossing the river Mures at the Arad Railway Bridge. The railway and steel bridge have been identified as significant sources of noise and vibration, and therefore CFR decided to investigate new technologies in track systems to reduce the transmission of vibration and therefore noise from the railway.

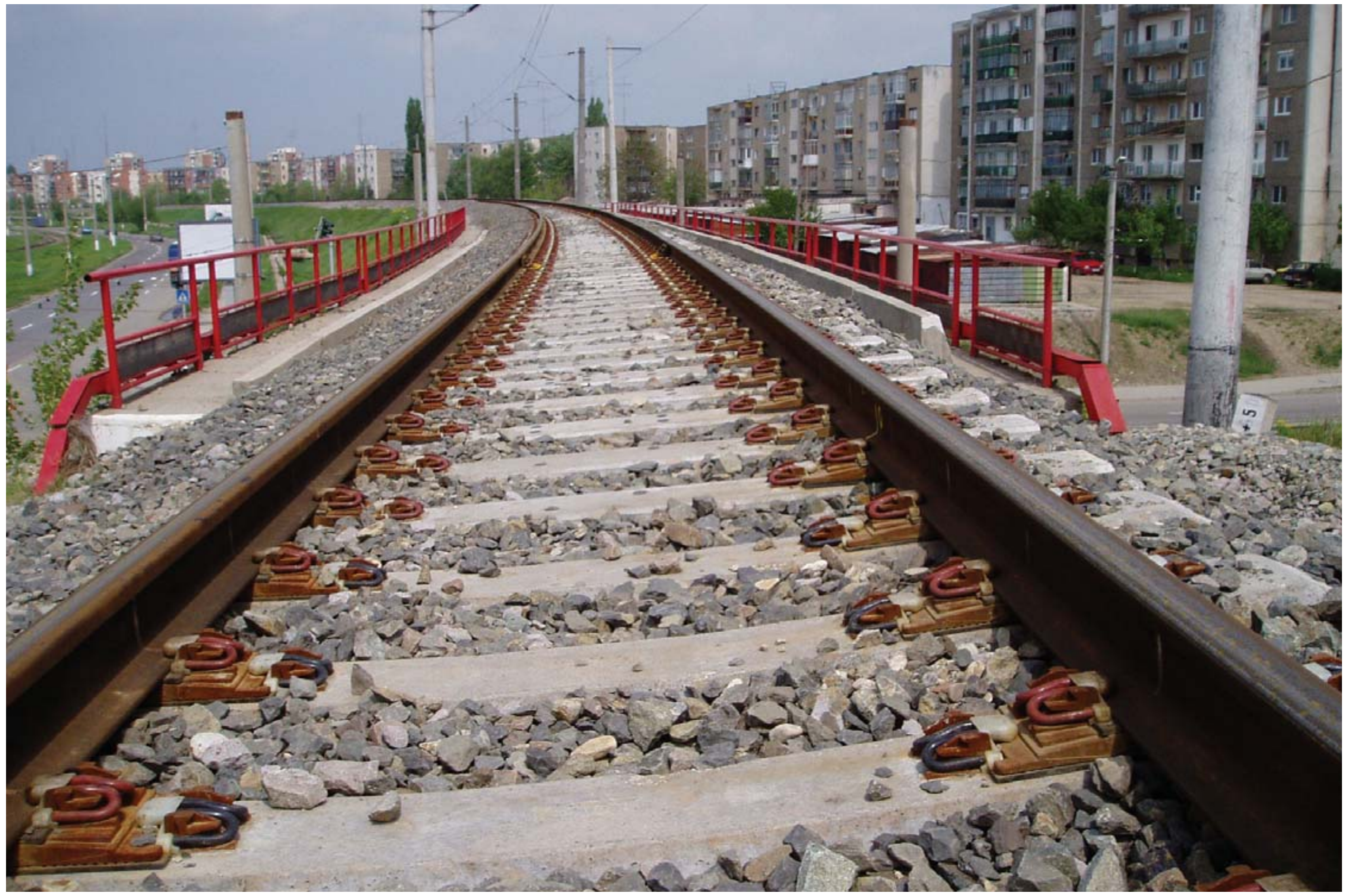
Reducing the transmission of vibration can be achieved by lowering the stiffness of the fastening system. On a steel structure, reducing the vibration also reduces the noise emitted from the bridge itself.

However, if very soft pads are fitted to standard fastening systems, then excessive gauge widening will occur.

Having evaluated other available systems, CFR specified the use of the Pandrol Double FASTCLIP system (DFC).

Pandrol Double FASTCLIP has a low system static stiffness of 25kN/mm. To prevent excessive gauge widening under traffic, this is achieved by the use of two studded rubber pads, one between the rail and top baseplate, and one between the top baseplate and bottom baseplate.

It is a non-bolted, resilient baseplated system that delivers substantial maintenance benefits, very important in areas where maintenance opportunities are limited and operational disruption costly. Maintenance



benefits include: no threaded components (plate hold down is by means of a second set of FASTCLIP components and a cast-in shoulder); easy inspection; and high electrical insulation through the use of the two double insulation layers. The assembly also allows for up to 10mm of gauge widening by the use of differing insulators on the lower baseplate.

The DFC is supplied as a pre-assembled unit to the sleeper factory, and arrives pre-assembled at the worksite.

The whole site was 8.6km in length, requiring a total of over 11,000 Pandrol DFC assemblies.

TRACKLAYING

Pre-prepared 25 metre concrete sleeper track panels, equipped with rails attached to the sleepers by the Pandrol DFC system, were laid onto a ballast bed prepared by a bulldozer using a Gantry Train, and crowbarred back to butt up to the previous panel.

On curves, the inner rail was unclipped, a suitable gap for the curve cut, and the rails were eased into a curve by crowbarring the sleepers. Reclipping took place when the correct curvature was achieved. The track was then manually aligned, again using crowbars. A worktrain then delivered ballast, which was distributed and the track tamped. ■

PANDROL VIPA-SP installation on Nidelv Bridge in Trondheim, Norway

by Stein Lundgreen, Senior Engineer, Jernbanverket Head Office

The present Nidelv Bridge in central Trondheim, built in the 1970's, is 190 metres long, consisting of two main types of bridge design: 147 metres is a steel box bridge with direct rail fastenings onto an enclosed load carrying steel box, and 43 metres of it is a bascule span with load carrying steel beams under timber sleepers.

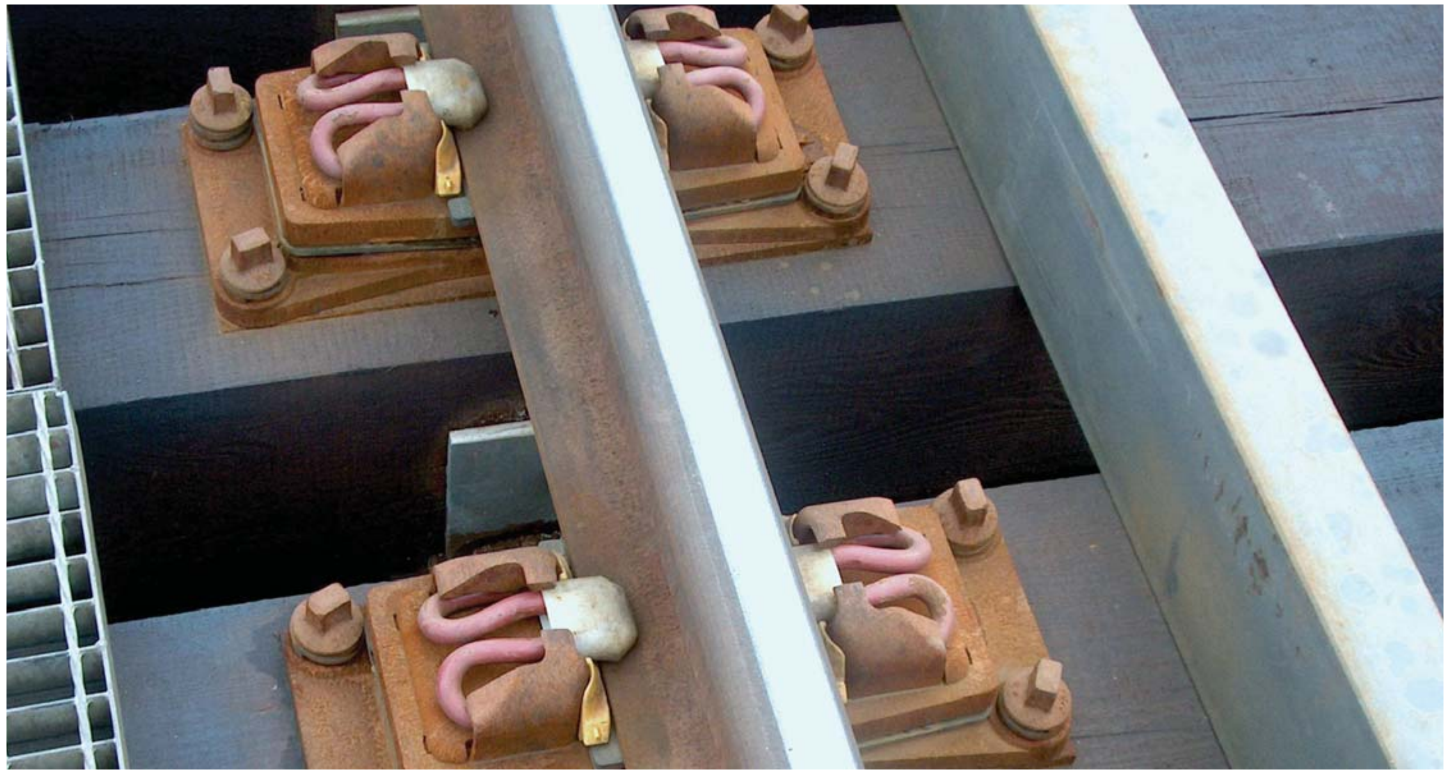
By 2002 the rails were worn and corrugated and needing replacement, and the area adjacent to the bridge was under development from having been dominated by industry and traffic to becoming an up-market office and residential area. A noise measurement report from February 1999 concluded that a noise reduction of at least 5dB was required. After having evaluated the various options available, Jernbaneverket decided to install PANDROL VIPA-SP to meet these requirements.

After completion of the installation in the spring of 2003 the noise measurements now showed a noise reduction of 14dB.

THE OLD BRIDGE

The bridge crosses the river Nidelv and is situated close to Trondheim Station. It carries the rail traffic to Bodø in Northern Norway and to Østerund in Sweden. As all trains stop at the station the train speed is low (40km/hr). There are two tracks across the bridge, but owing to a change in the traffic pattern only one of them

Commuter train BM92 passing over plate bridge



FIXED PANDROL VIPA-SP Assembly on timber sleepers

is in regular use. Therefore it was only necessary for the time being to carry out noise reduction measures on this track. To allow passage of boat traffic on the river there is a bascule span at the middle of the bridge on which wooden bearers are used.

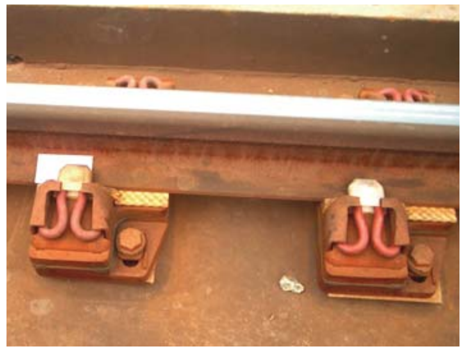
On some parts of the bridge the rail fastening is fixed; on other parts the rail is allowed to move longitudinally ('rail free'). Originally the fixed part had normal K rail fastenings, whereas the rail free part had ground off wedges in the K dovetail instead of the K clamp to allow the rail to move.

WORKS CARRIED OUT ON THE BRIDGE

Nidelv Bridge is 190 metres long. It consists of two main types of bridge design, 147 metres is a steel box bridge with direct rail fastening onto an enclosed load carrying steel box, and 43 metres is a bascule span with load carrying steel beams under timber sleepers. The two bridge designs are referred to as plate bridge and sleeper bridge respectively in this article.

On the 30 year old bridge repair works on the steel structure itself and upgrading of the bearings were also carried out.

To keep the rail free on a proportion of the fastenings a modified clip toe insulator has been used to prevent it from touching the rail foot. However, if the rail foot for some reason should be lifted up, it will instantly engage the full clamping force of the clip. To improve the



FIXED PANDROL VIPA-SP Assembly

handling characteristics of the product a sinusoidal polyurethane rail pad was supplied.

Design consultants were Aas Jakobsen AS; acoustics consultants were Brekke and Strand Akustikk AS; and Jernbaneverket Produksjon carried out the track renewal works.

The works performed related to noise reduction were:

1. The old rail fastening has been removed and replaced by Pandrol VIPA-SP fastenings. This is a system with a baseplate to which the rails are fastened by means of a normal FASTCLIP fastening and a rail pad, fastened to another steel Baseplate by means of a special arrangement; and a resilient pad is placed between the two baseplates.
2. Renewal of rails. Both old and new are S54
3. Installation of expansion joints
4. Replacement of wooden sleepers.

MEASUREMENT ARRANGEMENTS

Noise from the two types of bridge was measured at approximately 7.5 metre distance from the track in positions 1.5 metres above the track and 5 metres below the track respectively. Prior to the works noise was also measured at a position on shore at 7.5 metre distance, at a height 1.5 metres above the track.

An 8 channel DAT tape recorder was used for the recording of noise and vibrations.

Analysis were carried out with a dual channel Norsonic 840 parallel analyser.

Within the duration of the measuring works, which ran from approximately 08:00 until noon, 7 commuter trains class BM92 passed, as well as a freight train. Also, during the 'before' measurements, mainly BM92s passed. At the comparison of noise levels before and after, means values of 6 x BM92s before the works and 7 x BM92s after the works were used.

COMMENTS

For the sleeper bridge the improvement is 5dB. In Appendix A can be seen that the improvement in the lowest frequency area is considerably greater. Here the rail corrugations and noise emission from the large steel beams dominate the noise picture, and hence a great noise reduction is achieved in the lowest frequency area. It is the frequency region of 400-500 Hz which dominates the noise spectrum. The reason for this might be that the sleepers after renewal vibrate relatively freely, emitting noise. This is probably the main reason for achieving a lesser noise reduction on the sleeper bridge.

After the works there is approximately 4dB more noise from the sleeper bridge than from the plate bridge. Before the works it was the opposite: approximately 6dB more noise from the plate bridge. This applies to noise per unit length from the bridges. Comparisons of the frequency spectrae is shown in Appendix C.

As the measurements indicate our expectations to the noise reduction effect of the new design by far have been more than fulfilled; although it must be noted that some of the effect is due to the new rails which are not corrugated. ■

MEASUREMENT RESULTS

The results of the measurements in decibels can be summarised as follows:

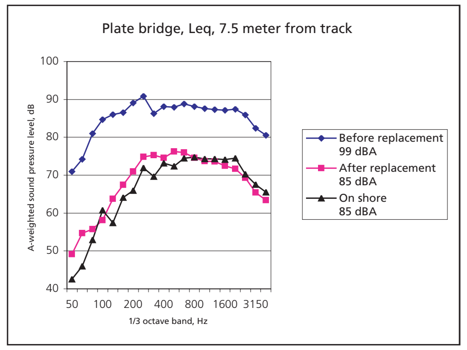
Plate Bridge	Before Works	After Works	Improvements
Measured 7.5 metres from track. H=1.5m	99	85	14
Measured under bridge	102	86	16

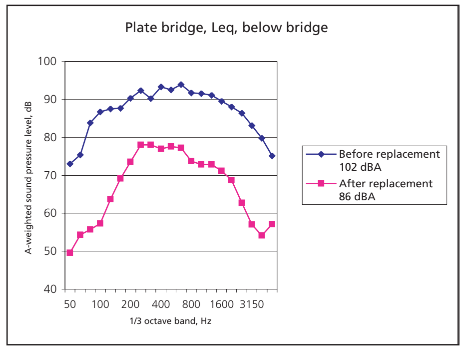
Results in frequency bands are shown in Appendix A.

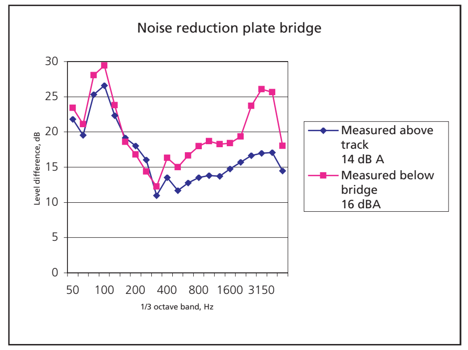
Sleeper Bridge	Before Works	After Works	Improvements
Measured 7.5 metres from track. H = 1.5m	93	88	5
Measured under bridge	96	91	5

Results in frequency bands are show in Appendix B.

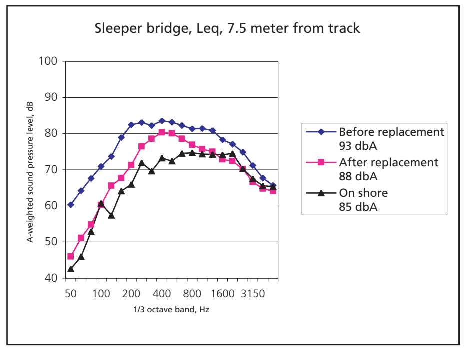
APPENDIX A - Measuring Results for the Plate Bridge

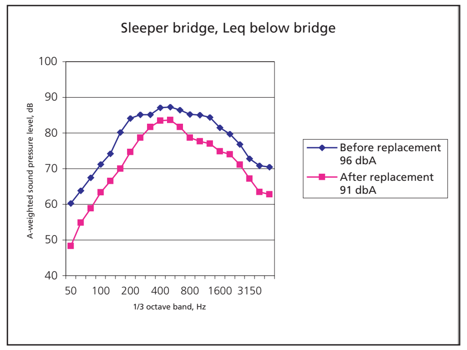


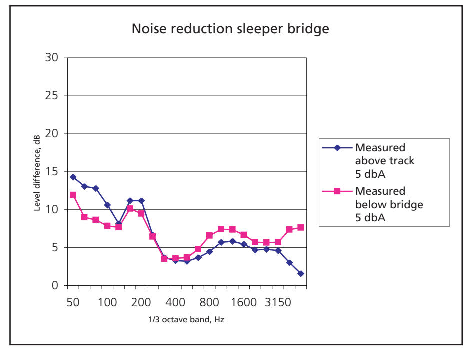




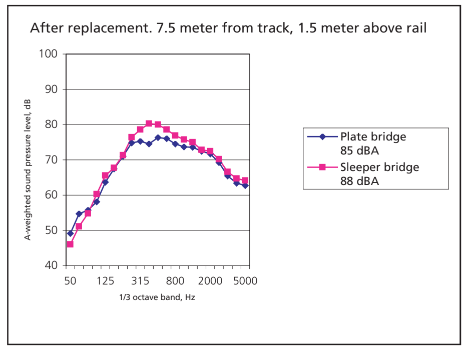
APPENDIX B - Measuring Results for the Sleeper Bridge

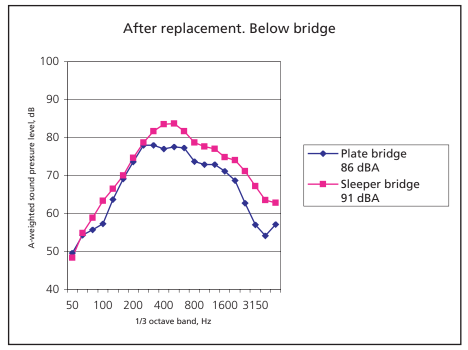






APPENDIX C - Comparison Plate vs. Sleeper Bridge after works





The Port Authority Transit Corporation (PATCO) goes High Tech with Rail Fastener

by Ed Montgomery, Senior Engineer, Delaware River Port Authority / PACTO

The Delaware River Port Authority (DRPA), the owner and operator of the PATCO High Speed Line, is undertaking the replacement of the existing direct fixation fastening system on the Westmont, Lindenwold and Collingswood Viaducts. The existing track fastening system is the original installation. The construction of the structures was completed in 1969. Based upon routine inspection reports, overall the structures are performing adequately. It was noted that the grout pads located under the direct fixation fasteners were deteriorating and routinely being replaced in kind. Owing to the deterioration of the grout pads and the existing direct fixation fasteners, the DRPA Consultant, HNTB, performed an industry review of direct fixation fastener systems to determine which products could be used to solve this maintenance problem.

DRPA, PATCO and their Consultant, HNTB, decided to build a hundred foot test section comprised of the existing revenue track which included an expansion joint, as a method of proving reliability under normal operating conditions. This includes test procedures that prove all electrical and mechanical criteria necessary to assure the successful operation on the PATCO system. The westbound track near Collingswood Station was selected as the test section.

An industry review of Direct Fixation Fastener (DFF) products and current technology was performed for application on PATCO's viaducts. This review considered existing vertical geometric constraints, overall stiffness, dynamic properties, electrical isolation, the interaction of the fastening systems with the viaduct structures, and the noise and vibration characteristics of five products. The review also considered possible grout materials for application with the direct fixation fastening system. HNTB visited the viaducts, reviewed DRPA-supplied drawings and reports, reviewed direct fixation fastener literature, met with vendors and analyzed the information focusing on the characteristics of the candidate fastener systems and the interaction of these fasteners with the viaduct structures.

A review of the original 1969 design drawings and other documentation was also undertaken. The drawings showed that the original trench for the direct fixation fasteners is one inch in total depth. HNTB calculated the height available for each direct fixation fastener product with the assumption that all the grout pedestals vary in height. The goal was to determine the geometry constraint for the new fastener. Because the geometry is constrained by both the existing deck slab elevation and the existing rail profile, the total height available from the bottom of the rail and the top of the existing slab is limited. This becomes the most critical constraint in the DFF selection process. The PANDROL PANGUARD* unit met all the criteria, including being the best for noise and vibration.

There are three viaducts to be refurbished under this project, Collingswood, Westmont and Lindenwold. The Collingswood Viaduct carries the PATCO High Speed Line's mainline double-track in the Borough of Collingswood, New Jersey. The eastbound track is on tangent alignment while the westbound track is tangent between stations and on curve within the vicinity of the station platforms. It is 2,522 feet in length and consists of 34 spans of varying length. The Westmont Viaduct carries the mainline double-track through Westmont, Haddon Township. It is on a nominal 9,280 foot radius curve. It is 1,970 feet in length and consists of 27 spans of varying length. The Lindenwold Viaduct carries two tracks over NJ TRANSIT Atlantic City Line and a PATCO access road. The 5 span structure provided access from the main line to the maintenance complex.

The viaducts are concrete structures with a minimum 8-inch thick concrete slab decks. Girders support the decks, which are in turn supported by concrete piers. The existing direct fixation fastening system uses the original 1969 design and is comprised of concrete/grout pedestals of varying heights with a #12 AREA tie plate, modified to accept two $^7/_8$" anchor bolts on a staggered placement. The pedestals are spaced approximately 30" on center throughout the viaducts. The rail is 132 RE held in place by two $^3/_4$" bolts with plate spring clips retrofitted to work on stock tie plates. Between the tie plate and the concrete pedestal there is a $^1/_2$" elastomeric pad. The viaducts have floating slabs on the approaches to the main structure. These are used to help transition from the ballast to the stiffer viaduct structure. The rail is continuously welded with only insulated rail joints for the signal system.

Original Direct Fixation Assemblies

Owing to the existing vertical constraint which allows for a total of $9^7/_{16}$" from the bottom of the grout trough to the top of the 132RE rail currently used, only the Pandrol PANGUARD system would fit within the existing envelope and maintain the fastener unit above the viaduct slab. This system was also rated the highest among the candidate systems with respect to noise and vibration ameleoration. It was decided to test the proposed system including the electrical characteristics in the viaduct areas and install an 80 unit test section of Pandrol PANGUARD fasteners to determine reliability of the product on the viaducts.

The current construction project involves the installation and evaluation of the test track section and performance of the fastener system. In the Pandrol PANGUARD assembly, the rail is supported under the head and in the web with a large elastomeric wedge, leaving the foot of the rail suspended above the base plate. The wedges are held in place by cast iron side brackets, which are then fastened to a base plate spaced at 2' 6" center to center. The grout pads combine two direct fixation fasteners with drainage breaks between the pads. The unique features of the fastener includes minimal rail roll, a very low profile which can be adjusted and a very low dynamic stiffness, similar to a floating slab but less expensive. Expectations are high by using this system the reduction in noise would be significant. The anchorage configuration includes 4 inserts with two inserts capped for future use in case of failure which was also designed to clear any deck reinforcement in the base slab.

The viaducts are multi-span, simply supported concrete bridge decks. Continuously welded rail is attached to the reinforced concrete deck by means of direct fixation fasteners. The primary forces that are transmitted to the viaducts are caused by longitudinal movements of the bridge superstructure, inducing forces in the direct fixation fasteners, which are transferred to the bridge bearings and substructure units.

Original specifications resulted in theoretical restraints ranging from 2.7 kips per anchorage to 2.2 kips per anchorage for a rail gap of less than $1^3/_8$". Maintaining the existing 30 inch center to center of fastener spacing, it is HNTB's considered opinion that a theoretical restraint bounded by the limits of 3.0 to 2.0 kips per fastener would not prove to be injurious to the structure. In addition the structural staff reviewed four direct fixation fastener products. The scope of the investigation included the review of the vendors literature, the results of testing presented by the vendors and interviews with their representatives.

Three of the products used the traditional clip method to attach the rail to the fastener. The classical method of the longitudinal restrain tests for the clip method of attachments is the loading of the rail in incrementally larger forces over time until slip occurs.

Pandrol PANGUARD differs from conventional resilient fasteners in its longitudinal loading behavior. Its longitudinal stiffness is lower than conventional fasteners and when slip occurs under longitudinal load, it still retains elasticity in order that increase in longitudinal loading is still required to increase deflection. On the other hand, the rail is free to move when slip limit is exceeded in conventional fasteners. Longitudinal behavior of PANGUARD is suitable for resilient fasteners applications on aerial structures as the loads transferred to the structure are reduced by PANGUARD. Furthermore, the longitudinal stiffness of the assembly can be modified if

Completed PANGUARD Installation

necessary by adjusting the clamping force on the rubber wedges that support the rail.

The ability of a rail fastener to decouple the rail from a structure and thus reduce the amount of structure vibration is related to the dynamic stiffness of the fastener. Fasteners with a relatively low dynamic stiffness will help to reduce vibration levels transferred to supporting structures, while fasteners with a higher dynamic stiffness will do little to attenuate vibration during system operation. This relationship assumes that the fastener design has no short circuits that would allow vibration energy to propagate from the rail to the supporting structure.

Previous vibration measurements showed that with the existing resilient fasteners, vibration levels between the rail and the deck differed by 10 to 20 dB in the frequency region between 31.5 and 125 Hz. Therefore, the new fasteners would have effectively to reduce the amount of vibration energy transferred to the structure and to ensure that structure radiated noise level does not increase, only rail fasteners that decouple the rail from the viaducts were considered.

Based on the technical information gathered and subsequent discussions with the manufacturers, it has been determined that the best, and only, viable choice for application on the viaducts is the Pandrol PANGUARD assembly.

DRPA and PATCO have recently contracted the consulting group of DMJM HARRIS to serve as the Project Engineer on the viaduct rehabilitation project. The project will be broken down into the three previously described phases of Westmont, Lindenwold and Collingswood. The 80 Pandrol PANGUARD assemblies have successfully completed the trial period and criteria without mishap resulting in PANGUARD being the chosen fastener for all three phases of viaduct rehabilitation. Approximately 7,000 PANGUARD assemblies will be required to complete all three phases which should be completed by the end of 2008. ■

** PANGUARD is known as VANGUARD outside of North America.*

Construction of the new LGV-Est — High Speed Connecting Central Europe

SNCF began developing the French network of high speed railways in the early 1980's, radiating from Paris. The Sud-Est route to Lyon opened in 1982, followed by the Atlantique Lines to West and South-West France, the Nord-Europe line running to Lille, Belgium and the Channel Tunnel, and extensions taking Sud-Est trains all the way to Marseille. Rèseau Ferrè de France (RFF) is now the owner of all the national railway network. This new state company is in charge of the construction of the HSR to the East, well known as LGV-Est.

TGV is not only about fast trains - speeds can only be safely achieved when running on specially designed tracks. Existing tracks must be replaced with new tracks known as LGV (Ligne à Grande Vitesse). Although the design of the TGV train does allow it to run on existing tracks, it cannot achieve its full speed. Whilst not all main-line tracks have been re-laid, some have been upgraded to enable higher speeds (up to 220km/h), without the cost of totally relaying the track.

The proposed LGV-Est (Ligne à Grande Vitesse) has been under discussion since the mid-1980's, with regards to the best route, and financial viability of construction, given that the line was unlikely to carry as much traffic as other lines under consideration at the time.

Finally in 1999, the French Infrastructure owner, RFF, received permission to construct a 300km line running from Vaires, on the Eastern suburbs of Paris to Baudrecourt near Metz and Nancy, Phase 1 of the new LGV Construction is being financed by the local government authorities and regions, with contributions from the French State, EU, Luxembourg, RFF and SNCF.

As far as journey time is concerned, with the first phase of the project up to Baudrecourt spectacular reductions are possible by June 2007: Paris to Reims from 1h:33mins to 0h:45mins, Paris to Luxembourg from 3h:37 mins to 2h:15mins, Paris to Strasbourg from 3h:52mins to 2h:20mins, Paris to Frankfurt am Main from 6h:19mins to 3h:45mins, Paris to Stuttgard from around 6h to 3h:45mins and Paris to Zurich from around 6h to 4h:30mins.

Civil works for Phase 1 of the East LGV should be reasonably straightforward - the route crosses hills, and does not require bored tunnels, however in Phase 2, between Baudrecourt and Vendenheim, the line crosses the Vosges mountains between the Moselle Valley and Alsace Plain.

The route of the East LGV, with its layout, bends and geometry has been designed by Rèseau Ferrè du France (RFF) to enable trains to reach a speed of 350kph. When it is brought into service in June 2007 the LGV Est will run commercially at a speed of 320kph, making the HSR to the east France's fastest train. To run safely at this speed, their position on the line and their speed have to be known at all times and there must be a means of communicating with them. The LGV Est will therefore be fitted with the very best electronic and telecom equipment. In addition to the French traditional signalling system known as TVM 430, it has a technological innovation known as the ERTMS (European Rail Traffic Management System), a string of letters used to show that Europe's rail network of the future is already under construction today.

DETECTING THE PRESENCE OF TRAINS

At present, high speed trains 'feel' the rail thanks to the train's wheels which 'short out' a low voltage current in the rail circuits. It is this that tells the control room exactly where the train is on the track. The data, which is essential for traffic safety and flow, is transmitted by cable. Once the control room receives the information, it is analysed and the controller sends the train back its maximum operating speed. This means that if a train stops between stations, all the other trains coming up behind it are informed.

Thanks to ERTMS, which is being developed throughout Europe, the aim is to enable trains run by any European operator to travel on the LGV Est system. In this new system the data is transmitted by optical fibres and microwave connections using GSM-R (a special GSM for railways), and is currently being developed by RFF, SNCF, the installation contractor, and their European counterparts. The aim is to make rail networks in France and neighbouring countries compatible, or 'interoperable'.

As soon as the LGV Est comes into service it will use both systems working in parallel. In 2007, SNCF's high speed trains will use one or other of these two signalling systems and GSM-R radio.

There are other technical developments provided by LGV Est, all of them synonymous with progress and quality. For example, the PANDROL FASTCLIP rail fastenings already widely used in other countries will replace the traditional 'screw in' clamps.

The FASTCLIP fastening is slightly elastic, ensuring perfect contact between rail and sleepers. Thanks to this product, coupling torque can be regularly inspected by video, cutting the costs of maintenance in the long term without any risk whatsoever. For the same reason the new link will use grease-free points and switches, installed CCTV or intelligent sensors and carry out ad hoc testing of track assemblies on single block sleepers or concrete platform.

TRACKWORK

On French high speed lines and the CTRL, equipment for tracklaying and catenery erection is mostly brought to worksites by rail. On the LGV Est three bases were established. The first, at Vadenay/Saint-Hilaire (Marne area) became operational in October 2004. The Ocquerre base (Seine et Marne area) officially opened its gates on 31st March 2005, and in May 2005 it was the turn of Pagny-sur-Moselle (Meurthe et Moselle area).

The LGV-Est is a double track line, using twin-block concrete sleepers with PANDROL FASTCLIP fasteners.

The margin of precision when laying the tracks is 5mm. The traditional way for the tracklaying to progress is as follows:

- Temporary track is laid, which carries the wagons transporting the rails for the permanent track - it is made up of recovered rails and wooden sleepers.
- Rails are delivered. These rails can be up to 400 metres long. For each track, the rail is first unloaded, then the twin block concrete sleepers, pre-assembled with PANDROL FASTCLIP fasteners, insulators and rail pads, are put into position on the bed. The rail is then threaded into the rail seat, and mechanically fixed in place by the elastic fasteners - the FASTCLIP that will be used for the first time on a French HSR.
- 5,000 tonnes of ballast is transported each day by rail and is unloaded on each side of the rail. Coarser, harder and more solid on an HSR than on traditional tracks, it will be changed every 25 years.

Tracklaying is advancing at a rate of 600 metres of double track each day (over 5,000 tonnes of ballast, 2,000 sleepers, 8,000 FASTCLIP fasteners, and 2,400 m of rails being the daily requirements for this).

Detailed pre-project studies of the second phase of LGV-Est, between Baudrecourt (Moselle) and Vendenheim (Bas-Rhin) have been completed. In the Bas-Rhine departement, second phase parcel surveys have taken place, acquisition negotiations have commenced and the regrouping procedures are on course. ■

Main Southern Line—New South Wales, Australia Installation of Concrete Sleepers

by Kerry Christie, Construction Manager South West, Rail Infrastructure Corporation - 2005

INTRODUCTION

During 2003, the Country South region of Rail Infrastructure Corporation installed 40,000 medium duty concrete sleepers on the Main Southern line between Breadalbane and Galong as part of the annual Major Periodic Maintenance program.

The concrete sleepers were installed in curves on a 1:4 pattern over a distance of 120km, this project is the first known major partial installation of concrete sleepers in N.S.W. This discussion paper summarises the innovation, preconstruction planning and installation process used successfully to deliver the objectives of the project. This paper also reviews RIC's sleeper renewal strategy, the project objectives and the immediate benefits that resulted from using medium duty concrete sleepers.

LOCATION DETAILS

The Main Southern line is a vital rail link between Sydney and Melbourne with 4 high-speed XPT passenger services per day and approximately 13.5 MGT of freight traversing the line each year.

The rail corridor south of Goulburn is double track, consisting of 53kg rail fixed to plated timber sleepers. Steel sleepers were installed in the track section south of Goulburn in 2000, to assist in retaining rail gauge. The steel sleepers were installed to a 1:4 pattern on curves and 1:6 on straight sections of the line, the number of steel sleepers amounts to approximately 10% of the total sleeper population.

The track alignment south of Goulburn varies between long straights at Breadalbane and tight compound curves of 300m radius through the Cullarin range. The Up main has a ruling grade of 1:75 and the Down main ruling grade is 1:40.

Over 70% of the track is curved with at least 30% of the curves being 450m radius or less. Road access is limited at a number of locations owing to the terrain, which consists of numerous steep embankments and narrow cuttings.

STRATEGY & OBJECTIVES

The strategic plan for the rail corridor north of Goulburn involved the progressive replacement of the existing aged timber sleepers utilising the face installation of concrete sleepers during annual total track possessions.

The installation of steel sleepers on the Main Southern line was seen as a short term solution to strengthen the track structure until sufficient funding was available and supporting construction processes to recommence the face installation of medium duty concrete sleeper program.

Owing to the poor condition of the existing timber sleepers on the Main line south of Goulburn a new strategic plan was developed that involved the progressive replacement of the existing aged timber sleepers in yearly cycles during partial resleepering utilising window track possessions.

Approximately 40,000 concrete sleepers were planned to be installed each year over a five year period commencing in 2003 between Breadalbane and Galong. In 2004 an additional 38,000 concrete sleepers were planned to be installed between Galong and Junee. And a second pass of 40,500 concrete sleepers was also planned to be installed between Breadalbane and Galong in 2005, which would have resulted in a 1:2 pattern on all tight curves.

The long-term outcome of this partial concrete resleepering strategy was for the Main Line south of Goulburn to be 100% concrete sleepered track, reducing maintenance costs and enabling the future use of high-speed production equipment. The short term objectives of the strategy was to improve the track stability on the Main Line by replacing the ageing timber sleepers with medium duty concrete sleepers which will directly contribute to the following benefits being achieved;

- A strengthening of the existing track structure.
- Improved track geometry and ride quality.
- Reduce annual maintenance costs, reducing the need to realign continually the track.
- Reduce the risk of misalignment in summer.

Why use Concrete Sleepers?

Concrete sleepers were selected owing to the increasing difficulties in procuring timber sleepers; the use of steel sleepers in partial resleepering is seen as a short-term solution only to maintain gauge. The extra mass weight provided by each concrete sleeper would also increase track stability (232kg).

BACKGROUND

TABLE 1 - SLEEPER SPECIFICATIONS

RIC County South has traditionally used the Pandrol 'e' Clip fastener with heavy-duty concrete sleepers during face laying operations on track-upgrading projects. RIC staff were very familiar with processes and resources required to layout jewellery and to clip up these types of concrete sleepers (Table 1).

The medium duty concrete sleepers manufactured by Rocla are currently available with two different types of fasteners, the traditional Pandrol 'e' Clip and the newer PANDROL FASTCLIP system.

In planning the Tahmoor to Bargo concrete closedown during 2002, it was decided to use FASTCLIP on medium duty concrete sleepers in lieu of the Pandrol 'e' Clip heavy-duty concrete sleepers. RIC was very interested in evaluating the new fastening system, as there were a number of known advantages from using the FASTCLIP fastening system;

- No material layout required as jewellery came fitted to the sleeper.
- Reduced manpower required to fit FASTCLIPS, walk behind clipping machines used on each rail.
- Ease of clip retraction and adjustment of rail during construction.

Type	Weight (kg)	Height (mm)	Length (mm)	Width (base)	Width (top)
Heavy Duty	285	227	2500	250	204
Medium Duty	232	178	2500	225	214

THE CHALLENGE

"To install 40,000 medium duty concrete sleepers in tight curves to a pattern of one in four on both the Up and Down tracks, over a 120km section of the Main Southern Line. Utilising pre-arranged window track possessions."

TRIAL UNLOADING, LAYOUT AND INSTALLATION

As this was the first major partial installation of concrete sleepers in N.S.W, there were no standard processes to follow and the project team raised a number of concerns over the most efficient methods to be used for the delivery, unloading, layout and installation of the concrete sleepers. To resolve these issues a four day trial installation project was planned and conducted at Cookes Cutting, south of Goulburn on the Down Main line in April 2003, utilising concrete sleepers manufactured from Rocla's Breamar facility.

The purpose of the trial

1. To quantify and document the existing capacity of RIC's Tie Renewal Team and their associated equipment, to install efficiently large numbers of concrete sleepers to a fixed pattern.
2. Identify areas in the process that were limiting production.
3. Trial several different consists to identify an optimum consists
4. Identify equipment shortfall and opportunities for improvement.
5. Evaluate the different types of on site conditions and their effects on production.

The results of the trial were then used effectively to plan and resource the main project. The following five main issues were identified during the trial.

Train Unloading

Timber and steel sleepers are easily unloaded directly from trains to the site by means of a mechanised unloading device. No such device is available to unload concrete sleepers beside the line for partial resleepering. Therefore the trial included the unloading of a 12 wagon, sleeper train in Goulburn Yard, to determine an efficient and effective process to unload the remaining 40,000 concrete sleepers.

Difficulties were encountered unloading the train owing to the way the timber was placed, dividing the load into four layers. Following, discussions with representatives of Rocla it was decided to alter the placement of the timber to allow for the load to be divided in to packs of 24 sleepers (6 wide x 4 high). These were nicknamed 'six packs'.

A specialised grab was manufactured for this purpose and the process has proved to be very successful. Currently a train load of 2,200 concrete sleepers can be easily unloaded in a rail yard within 5 to 6hrs, utilising a 30T excavator fitted with a sleeper grab capable of unloading 24 sleepers at a time. During the project, trains were unloaded along the running line at specific stockpile locations. This proved to be very efficient.

Sleeper Layout

The method to be used to layout all of the sleepers, prior to installation, was an important consideration owing to the restricted access to the track and the limited time available. During the trial in April, the sleeper pack concept also proved to be very easy to transport and layout. The sleepers were moved from the rail yard by flat top trucks to the worksite where they were unloaded with a front end loader which placed the sleeper packs alongside the track. A combination of bobcats, Hi Rail excavator and the 360 deg crane were then used to lay the individual sleepers on their marks, with an average of 600 sleepers being laid out on a daily basis which closely matched the proposed daily production rate.

During the project approximately 25,000 sleepers were delivered by train and 15,000 by road transport. In the final stages of the project, up to 800 sleepers (eight trucks) per day were being unloaded and laid out on site. In difficult terrain where access was limited on-track tie cranes and hi rail mini excavators were also used to layout and place the sleepers ahead of the resleepering team.

Concrete Sleeper Installation

During the installation trial an average of 400 concrete sleepers were installed each day. Unfortunately this was 250 sleepers per day less than the average production rate set for the main project, which was due to commence in July 2003.

Three major constraints to achieving the planned production targets were identified. For the project to be successful the main difficulties that were encountered during the trial had to be overcome, and several risk mitigation measures were developed and implemented. These included:

Excessive Ballast Build Up; Due to the added thickness of the concrete sleeper fitted with a FASTCLIP shoulder, it became necessary to increase the depth of excavation in each sleeper crib to facilitate installation of each concrete sleeper (+100mm). This extra excavation generated additional ballast, which could not be easily removed between the tracks, especially in areas of grade separation between the two tracks. The ballast build up at times prevented the new sleeper from being fully inserted under the rails.

A Hi Rail excavator was successfully trialled, which removed the excess ballast and increased the depth of area removed between the tracks.

Note the additional ballast build up in between tracks.

Lifting and clipping sleepers; At the time of the trial there was no machine available or capable of lifting a concrete sleeper and clipping up the fasteners in Country South. During the trial a tie crane was used to lift the sleepers and the clips were applied by two walk behind pedestrian clippers. These activities were also carried out manually using hand tools. However owing to the awkwardness and potential OH&S risk of this activity it was decided to source a machine that could perform both functions, lift and clip up.

Tie Crane & Mini Excavator lifting concrete sleepers with the FASTCLIPS being manually installed.

Wide Gauge; The design of the medium duty concrete sleeper has little tolerance for wide gauge resulting in the need for gauge correction to be carried out either before or during the installation of the sleepers. As the

Mini Excavator used for laying out and installing sleepers

PANDROL FASTCLIP

project scope planned to resleeper 105km of curved track, regauging would become a major issue and potential injury risk for staff.

As expected during the trial wide gauge was evident on each curve, which made it extremely difficult to efficiently clip up. Although manual hydraulic rams (gauge rectifiers) were purchased for this purpose they proved to be ineffective and awkward to use. It became obvious that a mechanised solution to facilitate regauging at each individual sleeper was required to improve productivity and efficiency.

As a result of the trial the following recommendation was made to senior management to improve productivity and efficiency.

"It is strongly recommended that attempts be made to acquire machinery to assist the sleeper clip-up process, as this would have the greatest positive effect on daily sleeper production. This machinery could take the form of an all in one machine that would lift the sleeper, rectify the gauge and apply the FASTCLIP's or just carry out one or two of these tasks. As stated any improvements to this clip-up process would improve the daily production of the entire consist."

PROCUREMENT OF SPECIALISED EQUIPMENT

Unable to source a suitable machine prior to the commencement of the project within Australia, we made enquires overseas and a Swedish company was recommended by Pandrol in the UK. Early discussions with Rosenqvist Rail Tech confirmed that it had previously manufactured and supplied several "Clip Drivers" with a proven ability to lift concrete sleepers and to apply all four FASTCLIPS in one operation. It was noted that the machine was primarily designed and used during new track construction where there were limited amounts of ballast on the track.

After further discussions it was also agreed to design and install a rail-gauging device on the machine to correct gauge at the time of sleeper installation. To meet the project schedule Rosenqvist fast tracked both the manufacture and the pre-delivery commissioning of the machine which resulted in the "Clip Driver" arriving in Australia only eight days before the project was planned to commence.

The "Clip Driver" machine although being a self contained unit is connected to a carrier machine, which provides electrical power and hydraulic pressure. The functions of the machine are controlled by the operator of the

Installed sleepers prior to clipping up

carrier machine. During the project both the 360 deg crane and a Hi Rail Petty bone were used for this task. The "Clip Driver" has become the backbone of the installation process combining sleeper lifting, gauge correction and the application of FASTCLIPS in one operation.

Due to the irregular sleeper spacings encountered the "Clip Driver" is supported by a small crew of three staff who man a correction trolley. One or two Mini excavators are also utilised in the clip up process were the track is close to gauge, this assisted in increasing production to an average of 1,000 concrete sleepers per day.

PROJECT STATUS REPORT

Despite a tentative start in July 2003, the daily production continued to improve with an average target of 800 sleepers per day installed easily achieved. The Project Manager advised that with some changes to the machine consist this target could be increased to at least 1,000 sleepers per day.

The efficiencies gained from the use of the FASTCLIP process contributed to the project running ahead of schedule due to the above average daily production rates achieved. To take advantage of being ahead of schedule an additional 1,900 concrete sleepers were installed over a 4km section of track on the Down Main Line.

The sleeper installation phase of the project was successfully completed during September 2003, with more than 40,000 concrete sleepers being installed. Despite the installation of some 160,000 fasteners and the regauging of 105km of main line track, NO injuries related to the installation process have been reported or recorded onsite.

This project was completed on time maximising the use of all track possession windows and at the same time delivered significant efficiency savings which can be directly attributed to the detailed pre construction planning for this unique project and the various innovations that were identified, developed and implemented during construction.

BENEFITS ACHIEVED

Recent inspection runs by RIC's track geometry recording car "The AK car" has indicated an improvement in all the major parameters Top, Line, Twist and Gauge. As a result the ride quality of this section of the Main Line has also dramatically improved. Comparisons between previous runs and the latest run were also carried out and this track data was used to verify;

- Increased track stability.
- Improved track geometry and condition.
- Improved rail gauge.

To evaluate the benefits and quantify the actual extent of track stability improvement achieved from installing concrete sleepers, a range of specific engineering tests were also carried out onsite in September 2003. These tests were designed to measure lateral and horizontal displacement of the rail head and foot of both the high and low rails.

This enabled us to calculate the amount of gauge widening evident before and after the concrete sleepers had been installed. The effects of gauge widening on the existing steel sleepers was also measured to determine if there had been a reduction in the load being applied to each of the existing timber and steel sleepers as a result of installing the concrete sleepers "load sharing". The longitudinal rail force was also measured to determine if the concrete sleepers restrain the rail more effectively as the temperature changed.

These test results all indicated that the newly installed concrete sleepers were in fact "sharing the load" and that the existing track had been effectively regauged, removing some 400 wide gauge defects significantly reducing the amount of lateral stress from each of the existing steel and timber sleepers which are under maximum load during each train movement.

SUMMARY

I consider that the first major project involving the partial installation of 40,000 medium duty concrete sleepers, utilising FASTCLIP fasteners on the Main Southern Line was a success. All of the project objectives have been met with the project being delivered to the prearranged possession schedule and significantly under budget despite increasing the scope of works. In addition the benefits resulting from this project have exceeded all of our expectations.

I would like to take this opportunity to acknowledge the contribution and effort of all those involved in the planning and delivery of this innovative project. This includes the RIC project team, local maintenance staff and our valued contractors who have all been committed to the projects success by overcoming adversity with a "can do" attitude. This combined with the continued support of Pandrol Australia, Rocla and Rosenqvist Rail Tech, made this project a resounding success. ■

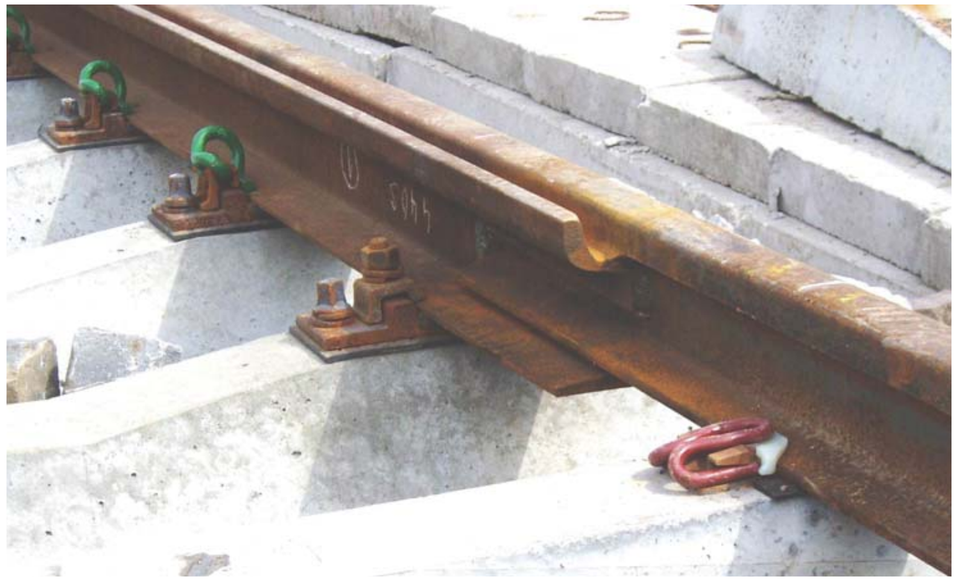
A completed section of main line track near Yass

Rosenqvist 'Clip Driver' with Hi Rail Pettybone

Light Rail Helps Solve Capacity Crisis

by Ddr-Eng Ion Dedu, Infrastructure Manager, Regia Autonoma de Transport Bucurestiet.

Over the next decade, the demand for public transport in the Romanian capital is forecast to grow by 20% as the metropolitan area continues to expand. To handle the business, we are upgrading many of our tram routes to light rail standards, building on the success of the first line since its conversion in 2002.



Bucharest has a population of about 2 million in an urban area of 228 km^2. RATB is the largest urban transport operator in Romania, handling 83% of all public transport trips on a 700 route-km network (double track). We have a market share of around 52% of motorised trips in the capital, although the capacity of our fleet of nearly 2000 trams, trolleybuses and buses is about 20% less than we need to cope with current levels of demand.

To tackle this shortfall, RATB's management is concentrating investment on high-capacity modes such as trams and light rail. Bucharest is fortunate that it still has an extensive and well-distributed tram network which has considerable potential for development.

The tram network was extensively modernised in the 1980s, but the prefabricated slab track technology available at the time has not proved adequate to cope with the increasing demand. Poor reliability, coupled with the traffic growth, led to higher levels of wear to the infrastructure.

As the rate of repairs could not keep pace, we saw a steady deterioration in track quality. At the same time, the number of operational incidents increased and the reliability and availability of the rolling stock fleet fell, leading to higher operating and maintenance expenses.

To restore normal standards and optimise the operation of the tram network, we recognised in the late 1990s that radical measures would have to be taken. These included a programme of infrastructure rehabilitation using new construction methods and rebuilding of the rolling stock. After evaluating the opportunities for financial support, RATB drew up short, medium and long-term strategies for development of the capital's surface public transport network. One short-term target has been infrastructure renewal on the tram routes in the southwest of Bucuresti, amounting in total to 110 track-km. This programme started with Route 41, which became the first light rail line in Romania.

ORBITAL PIONEER

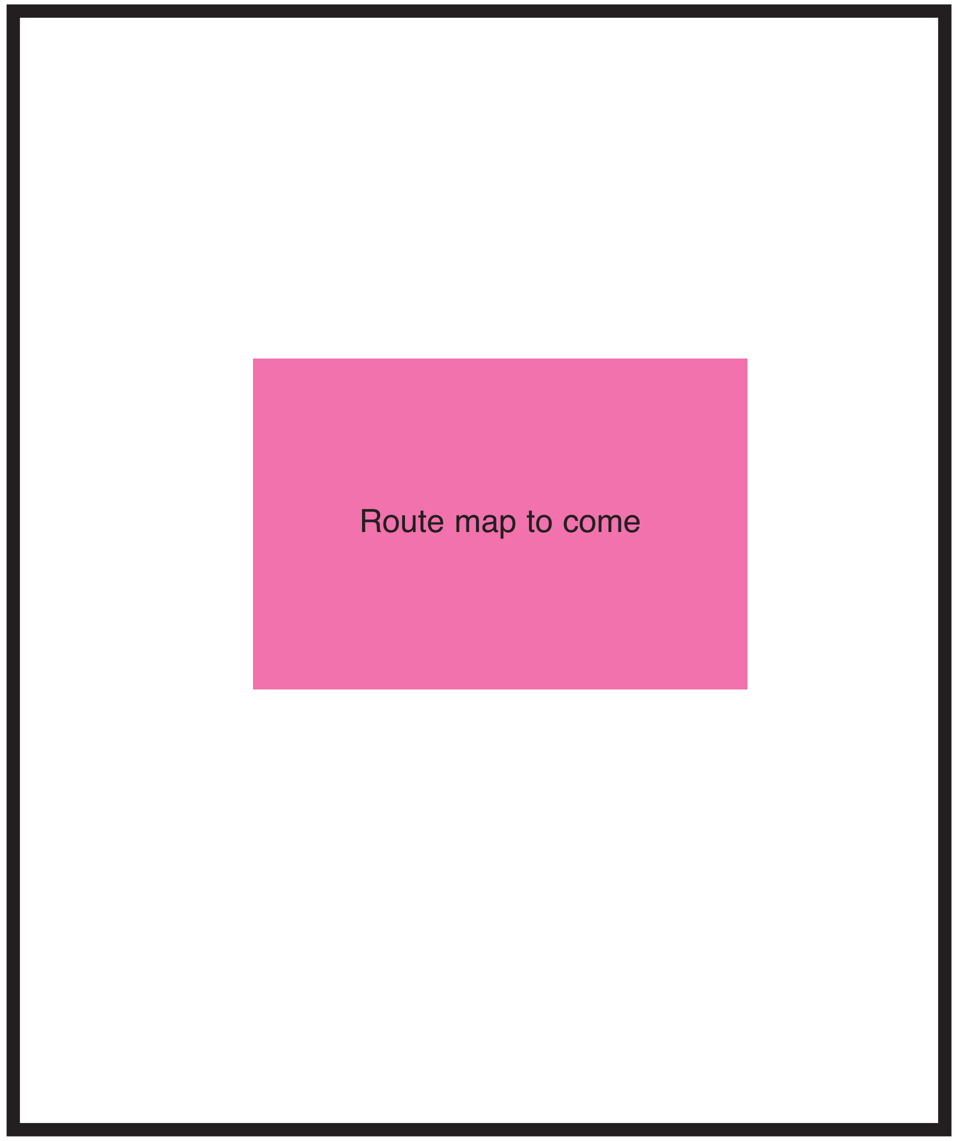
Route 41 was originally introduced in 1982 to give a direct connection between Piata Presei Libere in the north of Bucuresti and Cangrasi – one of the most populated districts on the city's western side. Three years later it was extended to the busy Steaua sporting complex in the southwest district of Ghencea. The 19.7 km route now serves five heavily-populated districts with a density of between 150 and 350 inhabitants/ha. Over the past 20 years demand on this orbital corridor has increased steadily, and Route 41 is one of the most important in the capital. Thus it was an ideal candidate to serve as the prototype for light rail upgrading in 2002.

For the majority of the line, we adopted classic ballasted track on a segregated reservation. Elsewhere we have used various types of track structure embedded in concrete. For straight alignments and curves greater than

200 m radius we used S49 flat-bottomed rail; NP4As grooved rails are used for tighter curves and special trackwork.

Steel quality is S 900A for rails used in alignment and in curves with minimum radius of 200 m and S 900V for curves with radius smaller than 200m and track crossing devices.

The overhead line equipment was upgraded from a single trolley wire to a double–balanced longitudinal catenary, making it more suited to higher speeds and increasing the cross-section to boost the power transmission capacity. To improve the power supply, extra substations were installed to keep the length of the DC feeder cables down to less



than 500 m. The line is now fed from seven substations – five new containerised units rated at 2.3 MVA and two existing 1.2 MVA installations. All of these will eventually be controlled remotely using a SCADA system. The two termini have been rebuilt as multimodal interchanges to facilitate the transfer of passengers. Platforms at the intermediate stops were rebuilt to accommodate higher passenger flows, in accordance with European standards on passenger safety, and redesigned to fit in with the local urban landscape.

To optimise the commercial speed of the service, a new traffic management system was installed which also provides real-time vehicle location and timetable supervision. At present there are 11 road intersections with traffic lights where the traffic management system is integrated with the city's SPOT/UTOPIA control network to give priority to the light rail vehicles. At these intersections, the traffic light cycles are adjusted to anticipate the heaviest traffic flows and optimise overall performance. This has helped to raise the commercial speed to 21 km/h.

REHABILITATED VEHICLES

With no finance available for new vehicles, rolling stock for Route 41 was rebuilt from existing V3A eight-axle trams which had been built in RATB's own workshops from 1973 onwards. The rebuilt three-section articulated cars each have a capacity of 300 passengers at $5/m^2$. The work included increasing the capacity of vehicles, installing modernised traction equipment to upgrade performance and maximum speed, and fitting visual and audio passenger information systems. Reconstruction of the route increased its nominal capacity from 4,000 to 6,000 passengers/h in each direction. However, the upgrading attracted more riders, and traffic rapidly exceeded the level forecast in the feasibility study. In order to satisfy this increased demand we had to raise the number of vehicles in use from 28 to 32, reducing the average peak-hour headway from 260 to 225 sec. During the reconstruction, considerable thought was given to future maintenance, and the track elements were designed for both a longer life and easier renewal. At the same time, specialised infrastructure maintenance equipment was procured. Together with changes to the maintenance and renewals schedules, this has helped to reduce the overall costs for track and rolling stock maintenance by about 80%.

Following the success of Route 41, RATB decided in 2003 to roll out the infrastructure

modernisation to further routes on the western side of the network, including routes 12, 32 and 35.

Bucharest Tramway has used Pandrol Rail Fastenings for part of its track rehabilitation for some years now, and Route 32 was being rebuilt using the Pandrol 'K' Conversion System, a simple method of converting existing rigid K Plate assemblies to resilient Pandrol 'e' Clip Assembies.

However, we were interested in evaluating the PANDROL FASTCLIP 'FD' system, which is a simplified version of the FASTCLIP system for railways operating low or medium density operations on rail sections of 50kg/m or below and at speeds generally less than 120km/hr. For this evaluation, 240 FASTCLIP 'FD' sleepers were included in the contract for Route 35.

The construction method consisted of short panels being built up on roughly graded ballast, a style of construction well suited to the FD system.

The sleepers were laid and rail pads fitted. Rails were installed and sleepers aligned. The light weight of the sleepers and lack of insulators at this point made alignment easy. As the FD pad has proper cut-outs, positioning of the rail to accept the insulators is easy.

The FD clips were then installed using handtools, and again, the lightweight of the sleepers combined with the relatively low toe load of the FD clip made installation very straightforward.

Overall, we were pleased with the system, and found it easy to install. Since the initial trial installation, we have installed a further 10,700 sleepers equipped with the PANDROL FASTCLIP 'FD' system, installed by one of RATB's appointed contracters, Marivilla, and a further 10,900 sleepers are ready to be installed by Themeli, another RATB contractor.

In the past year we have completed the upgrading of Routes 12, 32 and 35, and have nearly completed the modernisation of Alexandria and Militari Depots. Work on the other two tram depots has started, and we are now embarking on a programme to upgrade all the remaining tram routes over the next decade. The layouts vary because of local alignments, road conditions and demand, but in all cases we are following the principles established on Route 41.

LONG-TERM STRATEGY

Our citizens' demand for mobility is continuing to rise, and as the number of private car keeps growing, so do the traffic jams and air pollution. As its contribution to solving the city's long-term mobility problems, RATB has adopted an environmentally-responsible strategy to invest in high-capacity vehicles with minimum emissions, notably light rail, trams and trolleybus. To improve the city's visual appearance we have been experimenting with grassed tracks on the tramway reservations. This has proved very popular, and will be used extensively in future infrastructure rehabilitation projects.

Meanwhile, work has started on the first phase of the substation control system, which will eventually see all 20 tramway substations managed remotely from a single control centre. Four smaller area control offices will be provided for emergency backup. At the same time, as part of the ongoing fares integration process, RATB and metro operator Metrorex have started implementing a contactless smart card ticketing system. The winning bidder for this contract is a consortium of UTI Italy SRL, AP Trans SA, APB Prodata Ltda and UTI Retail Solutions SRL.

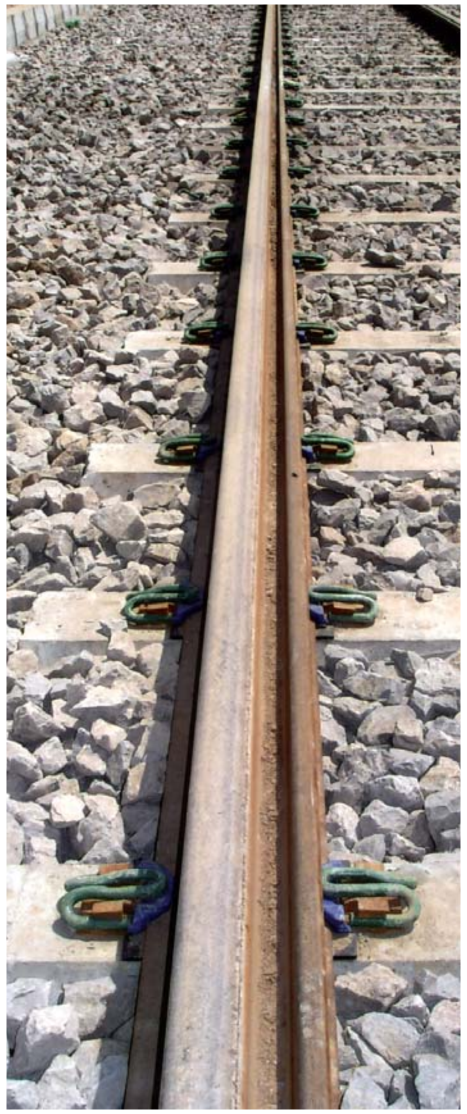
Integrated ticketing stands as a symbol for a closer working relationship between the city-owned tramway and state-owned metro networks, which will allow us to co-ordinate future development for the greater benefit of Bucuresti's citizens. A feasibility study is now in progress to set the priorities for modernisation of the tramway infrastructure in the north-to-southeast quadrant of the city, which forms part of RATB's medium-term strategy. The programme covers the rehabilitation of approximately 150 track-km, of which the great majority will be reconstructed to light rail standards, paving the way for expansion of the network in the longer term.

The rolling stock rehabilitation programme is continuing. The remainder will be replaced by new low floor vehicles.

We are currently working on the development of a prototype car with partial low floor and modern traction equipment, which has been completely developed and built in RATB's own workshops.

In view of the continuing growth of the Bucharest metropolitan area, we anticipate that expansion of electric rail services will be needed after 2012, investing in both metro and light rail to suit the various requirements. Extensions to the northwest, north, northeast and southeast are being studied.

Bucharest City has recognised that investment in attractive high quality, high capacity public transport is the only way to tackle the city's mobility problems. This is RATB's top priority, and we are rising to the challenge. ■



Pandrol VIPA-SP track-support for Leven viaduct in Cumbria

Network Rail decided to replace the steel deck structure of the multi-span Leven viaduct in Cumbria, which has been exposed to the harsh environment at the estuary of the River Leven for over 100 years. The steelwork had severely corroded and could no longer be maintained economically.

Network Rail appointed Carillion to undertake the contract, and the novel method proposed by them has achieved a dramatic shortening of the programme conceived by Network Rail. The original programme utilised two separate blockade periods in two financial years. Carillion has undertaken the replacement of the entire deck structure within a single 16 week blockade.

The deck structure carries a double track railway on the route between Barrow-in-Furness and Lancaster, and Network Rail had planned to replace a single track in each of two years. Carillion developed and implemented a dramatic acceleration in the programme by removing the inspection walkways on either side of the bridge and replacing them with load-carrying structural walkways on which they mounted two gantry cranes.

This simple expedient allowed the use of gantry cranes to both remove the old bridge units and place the new deck units. 48 of the 49 bridge spans were replaced with 96 deck units and accompanying walkways and the trackwork was completed and opened for traffic on time at the end of 16 weeks

Pandrol was able to provide an important innovation in the steel bridge design, which reduces the total weight of the structure, protects the original bridge piers from excessive vibration, and the local environment from re-radiated secondary noise from the new steel structures The Pandrol VIPA-SP system was chosen to meet the exacting demands of the renovated bridge, and assist to reduce the dead weight to be carried by the gantry cranes

This new track support system was chosen to fix directly to the steel structure

The traditional method previously used by Network Rail has been based upon the use of the longitudinal timbers, fixing normal baseplates to the timbers with screwspikes

Network Rail reports that it is increasingly difficult to obtain timber of the correct quality and price, and that this track form also leaves a significant maintenance liability for future years, especially in such an exposed coastal location. It was decided to base the new design upon Pandrol VIPA-SP, and marginally adapt the deck design.

The Pandrol VIPA-SP rail fastening system is a highly resilient baseplate which gives a vertical stiffness of only 20 kN/mm whilst controlling dynamic gauge widening.

This high resilience effectively isolates the bridge structure from high vibration levels, which as well as protecting the 150-year-old piers, will also reduce the re-radiated noise emitted from the bridge. A similar installation in Trondheim, Norway reduced wayside noise levels by 14 dB(A). The low stiffness will also spread the train loads over a longer length of track which permits a lighter weight bridge design. VIPA-SP reproduces the resilience of ballasted track, which alleviates the need for stiffness transitions on the embankments, and the high electrical resistance of the assemblies minimises the chance of circuit problems – essential for an all-steel bridge in an exposed, wet environment.

The coastal environment of the Leven estuary on the northern shore of Morecambe Bay suffers from the very fast-moving tidal flows, which make the Bay notorious, and extremely dangerous. The bridge decks were designed with longitudinal camber, in part to shed seawater, which can reach the deck in very high spring tides.

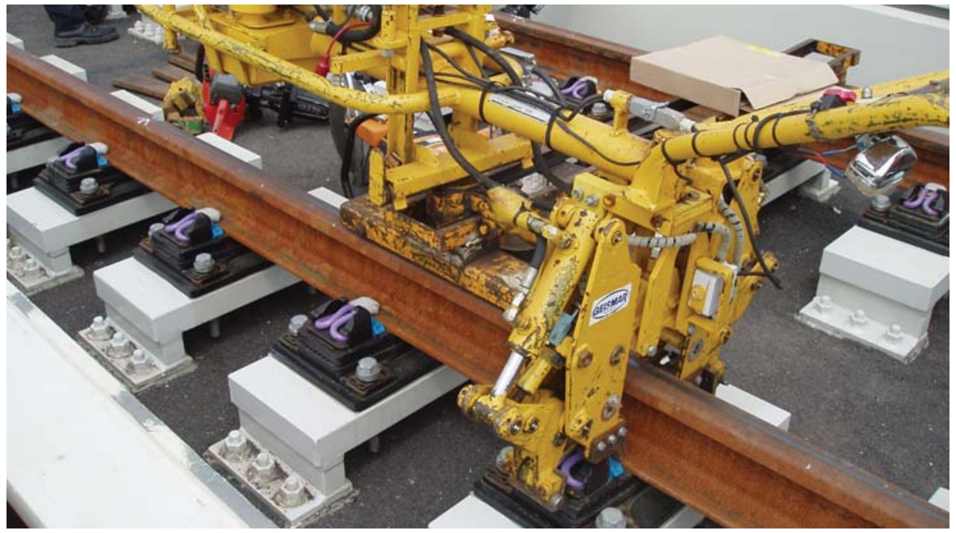
A major design parameter was for easy and rapid replacement of individual VIPA baseplates should it become necessary. It was decided to use an arrangement of steel 'stools' which would reduce the effects of the longitudinal camber, and ensure that the stools were co-planar by altering the leg-lengths.

This provided access to the hold-down assembly for the baseplates. The longitudinal camber was further accommodated by the

The Leven Viaduct

Threading Rail

Mechanical fastening of the PANDROL VIPA Baseplates was acheived using a Geismar AP11 machine



resilience of the VIPA assemblies. The through-bolting system for the VIPA could use nuts and bolts to secure the baseplates and the nuts could be easily located on the underside of the steel ‘stools’.

The VIPA system has been designed recognising the need for very close tolerance on the head of the rail during train operations. This tolerance is very much tighter than normally achieved by structural tolerance, and many of the discussions on the project centred on the need to achieve vertical tolerance of the rail to ± 1 mm. The steel bridge design became a ‘bottom-up’ construction on site, requiring the use of height adjusting shims to achieve tolerance, rather than pourable grouts. It was feared that grouts on steel would perform badly in this coastal environment.

Such construction methods are relatively new in this country, but Pandrol has experience of many worldwide installations of its products using various construction methods.

Thus, Pandrol worked closely with Carillion and Network Rail from the design phase and gave advice about construction methods. Pandrol also gave hands-on training and support on site, and provided a comprehensive Operations and Maintenance Manual to the maintainer.

The individual steel deck structures were delivered by road to the site depot outside Ulverston station and transported by rail the 3 miles to the northern end of the viaduct.

The ‘stools’ were used as lifting points to attach the gantry cranes upon arrival at the northern end of the viaduct. The deck units were installed on the new bridge bearings as accurately as possible, and then the trackwork commenced. The VIPA-SP assemblies were delivered to site in pre-assembled units, which combined with the use of Pandrol FASTCLIP within VIPA meant that installation time of the assemblies and rail was minimised.

The vertical height was adjusted using a variety of shims packed to fill the measured gap. Pandrol supplied a range of three differing shims of 3, 5, and 10 mm thickness. By combining these shims, the vertical accuracy was achieved. Carillion expected the worst-case construction tolerance to be ± 22 mm, hence the bridge was designed with a nominal 22 mm of Pandrol’s height adjustment shims which could be increased or decreased after a survey once the decks were in place. Thus a maximum 44 mm of shims and the thick steel stools required bolts lengths of up to 210 mm.

Pandrol worked closely with Carillion to gain approval for such long bolts, and performed fatigue tests and theoretical

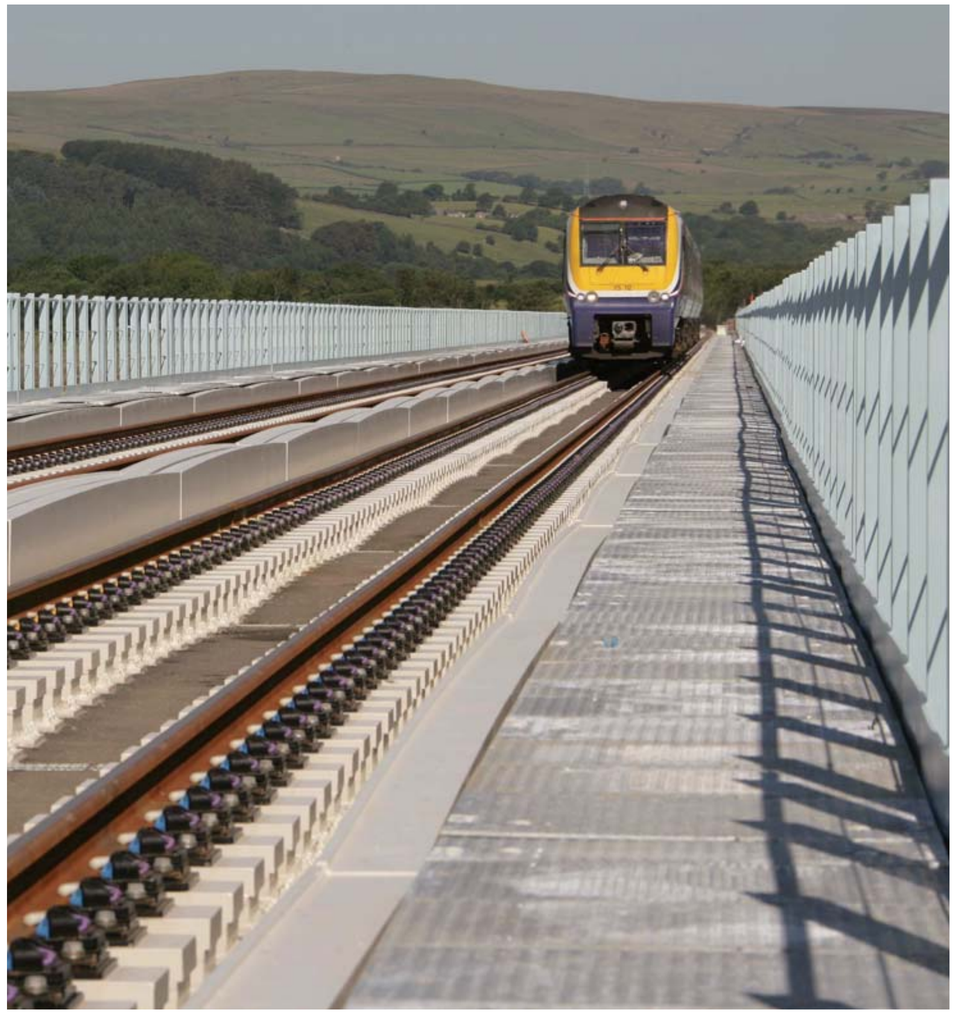
Lateral adjustment included in the PANDROL VIPA baseplates allows for accurate alignment of the finished track

calculations to prove the strength of the bolts to Network Rail.

The VIPA-SP baseplate provides slotted holes for lateral adjustment, which allow ± 20 mm for lateral alignment. The final track tolerance was achieved using laser equipment, which was aligned using traditional survey techniques. The photographs show the accuracy of the line and level of the rail, and Network Rail Territory office and the local maintenance department have been quoted as being delighted with the end results.

Network Rail has expressed the desire to adopt Pandrol VIPA-SP as the standard solution for steel bridges to eliminate the need for longitudinal timber and reduce the maintenance liability, and many other steel bridges are currently being specified to use Pandrol VIPA-SP. Thus these bridges will also benefit from reduced noise and vibration emission, enhanced ride quality, significant vertical and lateral adjustability, easy installation and high electrical resistance provided by Pandrol VIPA-SP.

The Leven viaduct has proved a successful bridge replacement contract and a major move to change the way that Network Rail specifies the track support system on steel structures. ■



CHANNEL TUNNEL RAIL LINK, UK

Transitions at the platform ends of St Pancras interim station provide progressively changing track stiffness between the concrete track slab and the ballast track beyond the station mouth. The track fastening systems change from untra-low stiffness VANGUARD on the concrete slab, through the intermediate and adjustable stiffness of PANDROL VIPA on both the slab track and timber sleepers in ballast, to the standard track stiffness of PANDROL FASTCLIP on concrete sleepers.

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